DEVELOPMENT OF THE NEW ZEALAND STIMULI FOR THE UNIVERSITY OF CANTERBURY ADAPTIVE SPEECH TEST-FILTERED WORDS (UCAST-FW)

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Abstract

Auditory processing disorder (APD) is a label that describes a variable set of symptoms that share a common feature of difficulty listening to sounds in the absence of an actual audiological deficit (Moore, 2006). Clinical assessment of APD typically involves a test battery consisting of tests designed to examine the integrity of various auditory processes of the central auditory nervous system. Individuals with APD have difficulty recognising speech when parts of the signal are missing. One category of tests used to assess the extent to which this deficit is associated with reduced performance on the task is the low-pass filtered speech test. The University of Canterbury Adaptive Speech Test-Filtered Words (UCAST-FW) is a computer-based adaptive low-pass filtered speech test developed for the assessment of auditory processing skills in adults and children. Earlier studies with the UCAST-FW (McGaffin, 2007; Sincock, 2008; Heidtke, 2010; Abu-Hijleh, 2011) have produced encouraging results. However, there appear to be a number of confounding factors. The UCAST-FW is testing New Zealand listeners using an Australian recording of American test material. The purpose of the current study was to develop a new four-alternative forced choice test to replace the Northwestern University Children's Perception of Speech (NU-CHIPS) stimuli the UCAST-FW currently utilises. The new test consists of 98 sets of four test items, (one target item and three foil alternatives) designed to be used in a four-alternative forced choice picture-pointing procedure. Phonemic analysis of the new word list and the NU-CHIPS word lists revealed a similar distribution of phonemes for target words of both word lists. The development of the new word list is described and the clinical applicability is explored.

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List of abbreviations

CANS: Central auditory nervous system

APD: Auditory processing disorder

CAPD: Central auditory processing disorder

OME: Otitis media with effusion

ADHD: Attention deficit hyperactivity disorder

ASHA: American Speech-Language-Hearing Association

NU-CHIPS: Northwestern University Children's Perception of Speech

WIPI: Word Intelligibility by Picture Identification

UCAST-FW: University of Canterbury Adaptive Speech Test-Filtered Words

UCAST: University of Canterbury Adaptive Speech Test platform

MAST: Monosyllabic Adaptive Speech Test

LPF: Low-Pass Filter

CVC: Consonant-Vowel-Consonant

CCVC: Consonant-Consonant-Vowel-Consonant

CHAPTER ONE

INTRODUCTION

Central auditory processing

The human brain is complex organ responsible for regularly carrying out a great number of central processes. One of these processes is our ability to hear, whereby auditory stimuli received from the peripheral auditory system are sent to the auditory cortex of the brain where it is consciously perceived as sound (Stach, 1998; Bamiou et al., 2001). The central auditory nervous system (CANS) is a structure responsible for this neural processing and manipulation of acoustic information transduced by the peripheral auditory system (Baran & Musiek, 1999; Moore, 2006).

Auditory processing ability is typically defined as the process by which the CANS relays information from the auditory nerve to the auditory cortex (DeBonis & Moncrieff, 2008). The CANS is a highly complex system of neural pathways that processes neural information received from both ears, and plays an important role in certain aspects of hearing, such as sound localization and extracting auditory signals from background noise. Normal functioning of the CANS can be affected by a number of developmental and pathological conditions from various locations in the auditory system.

Assessment of the CANS is important if a deficit in auditory processing is suspected. However, assessing the central auditory nervous system's ability to process auditory stimuli presents a challenge, due to the complexity of its neural pathways. Since the beginning of central auditory testing in the early 1950s, a number of significant research and clinical developments within the field of CANS assessment have led to the development of current procedures used to assess the integrity of the CANS (Baran & Musiek, 1999; Emanuel, 2002). Although the human ear is responsible for picking up sound and directing it to our auditory system, it is auditory processing that allows us to differentiate and interpret this signal.

Auditory processing disorder

Normal auditory processing refers to the efficiency and effectiveness by which the brain is able to use neural information from the auditory periphery based on certain characteristic features of the acoustic signal (Katz, 1992; ASHA, 2005; Moore, 2006). Auditory processing difficulties arise from an impairment of the ability of the brain to use and interpret this neural information. Auditory processing disorder (APD) is a term that describes a variable set of symptoms that share the common feature of difficulty listening to sounds in spite of normal peripheral hearing thresholds and normal intellectual capacity (ASHA, 2005; Moore, 2006).

APD does not describe a single deficit, but encompasses a variety of functions. It is associated with a range of impairments of auditory processing, characterized by poor performance in either one or more of the following areas:

- Auditory discrimination;
- Sound localization and lateralisation;
- Time-related (or temporal) aspects of audition;
- Auditory performance with degraded acoustic speech signals;
- Auditory performance with competing acoustic signals; and,
- Auditory pattern recognition (ASHA, 2005; DeBonis & Moncrieff, 2008).

There has been much debate in the literature regarding APD, ranging from how to diagnose and manage APD, to the terminology used to describe the disorder. As APD is considered a disorder that is central in nature, the literature currently refers to APD as either central auditory processing disorder (CAPD) or APD. The term APD will be used for the remainder of this paper for consistency.

Symptoms of auditory processing disorder

Aspects of auditory processing which are impaired in individuals with APD include temporal, spectral and binaural hearing, and also the ability to group and order sounds (Chermak & Musiek, 1997; Bellis, 2002; Moore, 2006). Individuals that are suspected to have APD frequently exhibit misunderstanding of messages, delayed, inconsistent or inappropriate responses when communicating, difficulties with sound localisation, difficulty with understanding speech in adverse listening environments, learning difficulties, an inability to ignore irrelevant background noise, and difficulty following complex auditory instructions (ASHA, 2005). Children who are affected by APD typically display listening difficulties, particularly when listening to speech in the presence of background or competing noise. Individuals that are suspected to have APD may display either one or more of the previously mentioned characteristics.

Auditory processing disorder remains a condition that is challenging to diagnose, as it frequently co-occurs with other language and learning disorders. Disorders such as dyslexia, attention deficit hyperactivity disorder (ADHD), and specific language delay make the diagnosis of APD difficult (Baran & Musiek, 1999; Moore et al., 2009). It is currently unclear whether APD occurs as a result of specific language or learning disorders, or plays a role in the subsequent development of these specific disorders.

Causes of auditory processing disorder

There is no known definite cause of APD in children or adults. However, one pathology that has been demonstrated to have an identifiable relationship with APD is otitis media with effusion (OME). A chronic conductive hearing loss such as OME results in a hearing loss which lasts for a period of time until it resolves by itself, otherwise medical or

surgical intervention is required. Chronic OME is a common condition among young children worldwide, especially among indigenous populations, including New Zealand Māori (Giles & O'Brien, 1989) and Australian Aborigines whose incidence rates of OME are among the highest in the world. Over time, recurrent middle ear infections, especially around the period where speech and language acquisition is critical, can result in interrupted acoustic input relating to speech and language development due to intermittent periods of adequate hearing.

These periods of poor hearing ability can result in reduced masking levels differences, a test of binaural hearing important for detection of sounds in noisy environments. Furthermore, temporal processing may be impaired following long-term OME, but can be reversed over time with adequate auditory stimulation and training to facilitate improvement in auditory processing abilities. However, although a history of recurrent OME is a common indicator of difficulties processing auditory information, this is not always the case.

Assessment of auditory processing disorder

APD is evaluated by a test battery consisting of simple behavioural tests and electrophysiological tests (Bamiou et al., 2001; Moore, 2006; DeBonis & Moncrieff, 2008). Prior to administering any behavioural tests, a baseline audiometric assessment must be conducted to rule out any existing peripheral hearing loss, which can confound test results (Bellis, 2002). This assessment should include obtaining both air and bone conduction thresholds, speech audiometry, and complete acoustic immittance testing.

Behavioural central auditory tests should include both verbal and non-verbal stimuli, be age-appropriate, and last for an amount of time appropriate for the individual's motivation and attention span (Bamiou et al., 2001). In addition to a baseline audiometric assessment and administration of behavioural tests, electrophysiological tests are a useful tool as they measure the brain's response to sound and provide information regarding the integrity of central auditory pathways. Moreover, there is a substantial amount of literature on electrophysiological correlates of many behavioural tests (Moore, 2006). However, electrophysiological tests are not always used, due to their sometimes taxing and costly nature. The typical components of a behavioural APD test battery include:

- *Monaural low-redundancy tests:* assess the ability of the listener to fill in missing or distorted portions of auditory stimuli, presented to one ear at a time.
- *Binaural integration tasks:* assesses the ability of the listener to process information being presented to both ears simultaneously, with different information being presented to each ear.
- *Binaural interaction tasks:* assess the ability of the listener to localise and lateralise auditory information and overall ability to detect signals in noise.
- *Binaural separation tasks:* assess the ability of the listener to process an auditory message coming into one ear while ignoring a different signal being presented to the opposite ear at the same time.
- *Auditory temporal processing tasks:* assess the ability of the listener to analyse acoustic events over time.

- *Auditory discrimination tasks:* assess the ability of the listener to differentiate between similar acoustic signals, differing in intensity, frequency, and/or time-related aspects (ASHA, 2005).

Interpretation of test results

There is no current gold standard against which APD is measured. However, there are several approaches that can be taken when interpreting diagnostic tests of APD. A commonly used approach is comparing an individual's test results to data obtained from a group of normal hearing individuals. This approach is commonly referred to as norm-based interpretation. Another approach, less commonly used, is interpretation of an individual's test results based on their own baseline of auditory processing ability. This approach is typically referred to as patient-based interpretation, and can include interpretations ranging from ear difference scores to comparing APD test results with non-audiological test findings such as cognitive test results (ASHA, 2005).

Interpreting APD test findings from a child poses its own challenges. It is at times difficult to interpret APD test battery results obtained from a child. Factors such as deteriorating motivation and attention to test stimuli can provide poor results on the test battery, and a genuine poor performance as a result of poor auditory processing ability are often hard for the tester to differentiate, and can confound test results.

Generally, a diagnosis of APD is associated with poor performance on two or more tests in the battery, requiring a performance of at least two standard deviations below the mean (Chermak & Musiek, 1997). In cases where a non-auditory confound is observed, such

as inattentiveness, a test result that meets the APD criterion should be interpreted with caution. The tester has the responsibility of, in addition to administering the test, being observant to qualitative indicators of behaviour that could confound the test results and re-administering tests where a diagnosis of APD is not certain.

Auditory processing disorder and monaural low-redundancy speech tests

Normal hearing individuals are able to fill in the gaps of speech where there are parts missing as a result of the redundancy of the neural pathways that are present in the auditory system (Bamiou et al., 2001; Bellis, 2002), and as such are often able to recognise speech when parts of the signal are missing, such as in tests where the signal is degraded by low-pass filtering. This ability is often not present in individuals with APD.

Monaural low-redundancy speech tests are tests that distort speech stimuli. These types of tests aim to assess an individual's recognition of degraded speech stimuli when presented to each ear separately (Bamiou et al., 2001; Emanuel, 2002). One method used to achieve this is by using a low-pass filtering technique to modify the frequency content of speech stimuli, which degrades the acoustic signal. As individuals with APD have difficulty filling in the missing piece of the speech signal when it is presented in such a degraded manner, monaural low-redundancy speech tests assess the extent to which this deficit is associated with reduced performance on the task.

Adaptive speech tests

There is a substantial body of research regarding adaptive procedures and their benefits when used in psychometric testing (Mackie & Dermody, 1986; Leek, 2001). The adaptive testing method allows participants to be assessed more effectively than constant-level stimuli, as the task is neither too difficult nor too hard to perform (Bochner et al., 1996). The adaptive procedure involves changing characteristics of the stimulus (such as its presentation level), in a manner which is dependent on the participant's response to the previous stimulus. In short, correct responses make the following stimuli harder to identify, where incorrect responses render subsequent stimuli easier to identify.

A benefit of the adaptive procedure is that the performance level of the participant during the testing process determines the recognition threshold, which eliminates the need for a fixed presentation level (Mackie & Dermody, 1986). This results in each test item being at a level of difficulty appropriate for the participant's specific ability, and therefore avoiding the floor and ceiling effects that occur when using stimuli presented at a constant level. An advantage of adaptive speech testing is the increased efficiency compared to speech tests that are presented at a constant level (Elliott et al., 1979; Mackie & Dermody, 1986). Adaptive speech procedures reduce experimental time and increase accuracy as each trial is determined by the participant's performance on previous trials, avoiding stimulus levels far from a target threshold value (Leek et al., 1992; Leek, 2001). Moreover, administering such tests with a computer enables much more flexible and efficient testing, and enables large amounts of data to be automatically collected, analysed and stored.

Forced choice testing

A “forced choice” or “closed set” test is a method of determining a response to a given stimulus, whereby the participant must select one of a number of predetermined options (Leek et al., 1992; Leek, 2001). A benefit of speech tests that are presented in a forced choice format is that minimal training is usually required as the task is highly repetitive and participants learn quite quickly to pair the acoustic stimulus with one of the presented options (Foster & Haggard, 1987). Furthermore, there is more control over the participants’ response. Verbal responses can be highly variable and at times hard to interpret easily; the forced choice format removes this ambiguity.

Leek (2001) stated that the most common forced choice method was the two-alternative forced choice method. However, utilising forced choice procedures with more than two alternatives lowers the likelihood that correct responses made may be attributable to chance. Compared to tests with a large number of options to choose from, the four-alternative forced choice format requires less time to visually scan and select an item (Foster & Haggard, 1987).

The four-alternative forced choice method is an overall compromise on the ease of response required for the task, and the amount of information presented. However, a possible disadvantage of using a forced choice test format could potentially make a participant who is genuinely unsure about the correct response uncomfortable with the task, and subsequently lose interest in the task (Kaernbach, 2001).

A number of forced choice tests were developed for clinical speech audiometry in the 1970s and 1980s, including the Word Intelligibility by Picture Identification (WIPI) test (Ross

& Lerman, 1970), The Goldman-Fristoe-Woodcock Test of Auditory Discrimination (Goldman, Fristoe & Woodcock, 1971), Northwestern University Children's Perception of Speech (NU-CHIPS) test (Elliott & Katz, 1980), and the Picture Identification Task (Wilson, 1980). More recently, the University of Canterbury Adaptive Speech Test-Filtered Words (UCAST-FW), a four-alternative forced choice adaptive speech test, was developed for the assessment of APD in both adults and children (McGaffin, 2007; O'Beirne, 2009; O'Beirne et al., 2012).

The University of Canterbury Adaptive Speech Test-Filtered Words (UCAST-FW)

The University of Canterbury Adaptive Speech Test-Filtered Words (UCAST-FW) is a computer-based adaptive low-pass filter speech test developed for the assessment of auditory processing skills in adults and children. The UCAST-FW was developed by Dr Greg O'Beirne and implemented using National Instruments Lab VIEW 8.20 (McGaffin, 2007; O'Beirne, 2009; O'Beirne et al., 2012). This computer-based adaptive speech test is intended to improve the sensitivity and efficiency of the low-pass filtered words test, compared to other low-pass filtered speech tests that are presented at a constant level. The UCAST-FW was developed to assess the auditory processing skills of adults and children, and aims to differentiate performances of individuals with suspected APD and normal hearing listeners.

The UCAST platform was inspired by the monosyllabic adaptive speech test (MAST) protocol developed by Mackie and Dermody (1986), and currently utilises the NU-CHIPS stimuli, which consists of visual and speech stimuli in a forced choice four-alternative option format. While the MAST was a manually implemented adaptive level test to determine

speech reception threshold, the UCAST-FW is a computer-based adaptive low-pass filter (LPF) test, adjusting the LPF and tracking the corner frequency at which participants are able to identify a certain percentage of the words presented. Earlier studies with the UCAST-FW (McGaffin, 2007; Sincock, 2008; Heidtke, 2010; Abu-Hijleh, 2011) have produced encouraging results.

McGaffin (2007) found that adult participants with normal hearing performed significantly better than children with normal hearing on the UCAST-FW, which was at the time referred to as the University of Canterbury Monosyllabic Adaptive Speech Test (UC MAST). Furthermore, the same study found that adult participants performed more reliably on the UCAST-FW compared to child participants. In another related study, Sincock (2008) found that adaptive speech testing using the UCAST software platform as an adaptive level test produced an improvement in time efficiency, reliability and overall suitability of using an adaptive procedure for conventional speech audiometry.

Current drawbacks of the UCAST-FW

Although there have been previous studies demonstrating the effectiveness of the UCAST-FW, there are a number of confounding factors. In short, the UCAST is testing New Zealand listeners using an Australian recording of American test material. Firstly, the current visual stimuli for the NU-CHIPS word lists are outdated. This produces a need for new visual stimuli to be developed. Secondly, the word lists currently used for the acoustic stimuli of the UCAST-FW, the NU-CHIPS word lists, are not spoken by nor designed specifically for New Zealand English speakers.

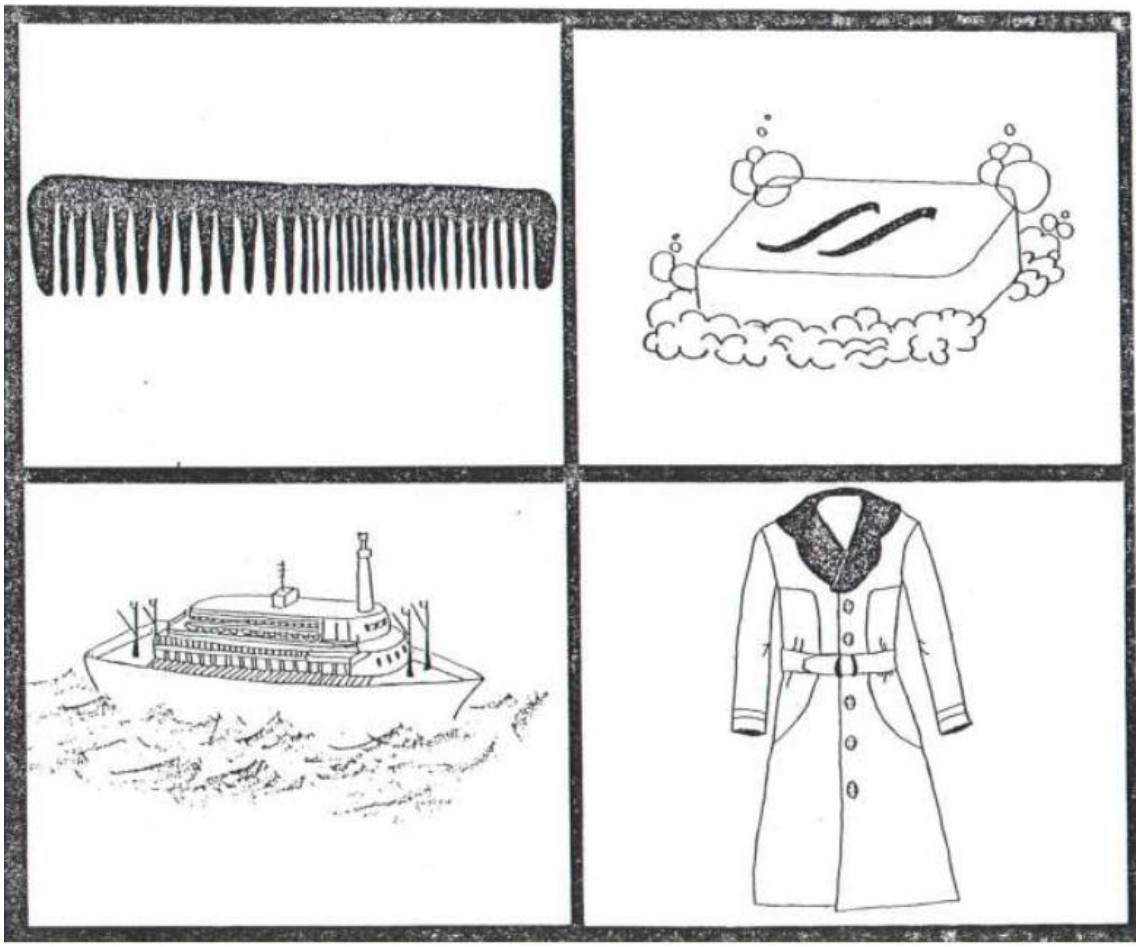
As the current UCAST-FW stimuli were originally developed for listeners of American English, they may not apply to New Zealand listeners of English in the same way they apply to American listeners of English. Therefore, it is not unreasonable to assume that a New Zealand listener of an American English sample recorded in Australian English might not give a performance that is truly representative of their auditory processing ability. This produces a definite need for a new four-alternative forced choice test, using words and pictures that are appropriate for New Zealand, and also Australian populations. Development of new visual stimuli will commence following development of the new test material.

The NU-CHIPS test of speech discrimination

The NU-CHIPS test of speech discrimination was developed by Elliott and Katz (1980) for the purpose of assessing the speech discrimination abilities of children having receptive language as young as three years of age. The test comprises of four lists (Test Forms) of monosyllabic, consonant-vowel-consonant (CVC) format words, in a forced choice, four-alternative format. Each of the four Test Forms contains the same 50 monosyllabic words; two Test Forms comprise Book A, and the remaining two Test Forms make up Book B. Each Test Form is randomised differently so that each has a different arrangement of monosyllabic words, and subsequently correct test items (or "targets"). The four Test Forms were originally recorded by a male speaker of American English, but are also available in a female-talker version. The original method of responding required the participant to point to each picture they thought was the correct option. Figure 1 shows a original test plate for the stimuli "coat" (Test Form 1) and "comb" (Test Form 2). Based on the response, the

tester marked each word as correct or incorrect, leading to a final percentage of correct words obtained.

Figure 1
Original NU-CHIPS Test Plate



Prior to testing, Elliott and Katz tested each child's vocabulary by administering the Peabody Picture Vocabulary Test, a receptive vocabulary test. This ensured that each child's receptive vocabulary was adequate for the administration of the NU-CHIPS. They also stated that the procedure for administering the NU-CHIPS could be modified if required. Modifications would be based on the specific needs of the participant. For example, the NU-

CHIPS test material would be appropriate for stroke patients previously having normal language development, individuals who do not have English as their first language, and individuals presenting with a significant developmental delay.

Rationale of the NU-CHIPS test

The original purpose for developing the NU-CHIPS word lists was to: (1) Be appropriate for children and others having a receptive vocabulary as young as three years of age; (2) Be phonetically representative; (3) Require a picture pointing response; (4) Have tape recordings available; (5) Provide equivalent forms so that multiple tests can be administered; and (6) Permit flexibility in clinical administration (Elliott & Katz, 1980).

The stated rationale for the NU-CHIPS word lists, as published, was to develop a new children's test of speech discrimination which permitted the assessment of children as young as three years of age. At the time of development of the NU-CHIPS, speech discrimination tests available contained vocabulary items that were too difficult for children having a receptive vocabulary less than five or six years of age.

Development of the NU-CHIPS test stimuli

The foils and target items chosen for the NU-CHIPS were based on the stimuli developed during the course of a previous study (Elliott et al., 1979). This study involved the initial selection of 131 monosyllabic nouns from children's books and vocabulary lists. Pictures representing these words were taken from magazines, so that each monosyllabic

word would be visually represented. These monosyllabic nouns were assembled onto pages in a scrap book type format.

Pilot testing of the response pictures and the recordings of the words were conducted simultaneously. The initial pilot test involved grouping all 131 chosen magazine clippings of the monosyllabic nouns into groups of four onto pages. A group of twenty-five 3.0 - 3.6-year-old children having English as a first language were tested. Stimuli were delivered using a randomised order for each presentation. This procedure involved an examiner who showed each page to the child and asked “show me the___”. Children were required to point to the picture they understood was spoken by the examiner. Results from this initial testing phase showed that 67 of the 131 words were correctly identified by at least 22 out of the 25 children tested.

Further testing of the correctly identified words was undertaken. This testing phase involved using a tape recording of the words, first spoken by a practiced student radio announcer having a General American dialect. In addition, line drawings of the 67 words were prepared by an artist and assembled into response books. The response books were arranged so that each page would display a set of four pictures, where each picture represented a particular monosyllabic noun. Tape recordings and artist-prepared pictures were tested on a different group of 3-year-old inner-city children. Testing revealed that some children found it hard to understand the talker even at a comfortably loud level, and some of the pictures required alterations to make them easier to recognise.

Successive testing phases were carried out. A second talker was used for an additional recording of the test material due to difficulties some children experienced understanding the previous recordings. Talker two was a doctoral student phonetician having a General

American dialect, and was used to re-record some of the words. In addition, some pictures were also re-drawn. The new recordings and modified pictures were tested on a new group of ten 3-year-old children from day-care centres. Results were acceptable enough for retention of all the 67 recorded words.

Further testing was undertaken to adjust the intelligibility levels of the recorded words. Previous pilot testing revealed some words were not as equally intelligible as others at presentation levels close to hearing threshold in both quiet and noisy conditions. This was necessary because the words were to be used in an adaptive procedure. The relative intensities of each test item were equalized.

The final phase involved a reduction of the most recent list of 67 words to 50 words, an examination of the phonetic representativeness of the reduced list, and arrangement of the stimuli onto pages. The new pool of 50 words was established by eliminating words that had significantly high or low percentages of correct responses. The authors considered the phonetic characteristics of the remaining 50 words to be good. Table 1 below displays the final list of target words.

Table 1
NU-CHIPS Target Words

ball	cup	gum	meat	snake
bear	dog	hair	milk	soap
bike	door	hand	mouth	spoon
bird	dress	ham	nose	teeth
boat	duck	head	purse	tongue
bus	food	horse	school	train
cake	foot	house	shirt	tree
clock	frog	juice	shoe	truck
coat	girl	light	sink	watch
comb	gun	man	smile	witch

Two response books, Book A and Book B, were developed to represent the sets of targets and foils. In each book, the final reduced list of 50 words represented target words, while foils were chosen from the previous list of 67 words that survived the original selection of items for 3-year-old children. For both Books, each set of four words were selected according to the criterion that the foils have as much phonetic similarity to the target words as possible, with some sets containing random arrangements of targets and alternatives. By using two picture response Books and four Test Forms, the number of different combinations of the test material was greatly increased.

Elliott and Katz developed a word list that consisted of phonetically balanced drawable monosyllables that were documented to be in the recognition vocabulary of normally developing American children 3 years of age and older. The final version of the NU-CHIPS word lists and the colour-coded legend is presented in Appendix A.

Applications of the NU-CHIPS test

It could be assumed that, due to the close geological proximity of Australia to New Zealand, a similar version of English may be spoken by Australians. This would expand the clinical applicability of the UCAST-FW to include both New Zealand and Australian populations. However, studies have revealed that Australian English may be becoming less similar to New Zealand English, rather than becoming more similar (Watson et al., 1998). Block and Killen (1996) found results that suggest a difference in speaking rate between the two types of English, with New Zealand English being spoken at a faster rate than Australian English.

In addition, accent differences between Australian and New Zealand English can change the way some words are perceived, particularly words ending in the consonant /l/. Words that sound similar in a New Zealand accent can sound markedly different in an Australian accent. For example, the words “pool” and “pull” sound similar when spoken in New Zealand English but not when spoken in Australian English, as more emphasis is placed on the vowel /ʊ/ when spoken in an Australian accent. It is not unreasonable to assume that when the speaker’s accent is changed, the listener may perceive target words differently, leading to errors.

Stimuli appropriate for a new test of speech discrimination

There is a need to develop a new speech discrimination test appropriate for the assessment of APD in New Zealand children. Although there are many speech discrimination tests available for testing children, many have characteristics that make them inappropriate

for use in a number of clinical situations. Such situations include vocabulary items that are unfamiliar to young New Zealand children, and testing procedures that require a "talk-back" response.

Furthermore, tests which utilise sentences as test stimuli would not be appropriate for testing the speech discrimination abilities of young children. Sentences, compared to monosyllabic words, would make a non-verbal picture-pointing response far more difficult as sentences would be significantly harder to visually represent in a single picture. In addition, Boothroyd (1985) reported that words in sentence context are more likely to be recognised than words presented in isolation. This relates to the influence of linguistic context on recognition probability (O'Neill, 1957).

Speech discrimination tests which require a picture pointing response to an auditory cue can engage a young child's interest due to the presentation of novel visual stimuli. However, the use of pictures in a speech discrimination test to elicit a response assumes that each picture, including the target items and the foils, are able to be recognised by the participant without any assistance from the tester or any other cues that might assist picture identification. Children who are not able to recognise the pictures as matches to the presented auditory stimulus raises the question as to whether the child's ability to correctly identify visual stimuli is actually being tested, instead of the child's ability to correctly discriminate speech stimuli (Dengerink & Bean, 1988). The WIPI and the NU-CHIPS are two examples of tests designed to assess children's speech discrimination abilities requiring picture pointing as a required response.

Requiring participants to verbally respond to test stimuli was considered to be inappropriate, and unnecessary for administration of the UCAST-FW. As the NU-CHIPS word

lists are presented in a forced choice format, requiring participants to elicit a verbal response would provide an opportunity for words not included in the four-alternatives to be spoken. A benefit of the non-verbal response format of the UCAST-FW is that potential participant articulation difficulties do not hinder the administration and correct scoring of the test.

For these reasons, drawable monosyllabic nouns and a non-verbal picture pointing response were essential for the development of the NU-CHIPS word lists (Elliott & Katz, 1980), and also for the development of a new four-alternative forced choice test appropriate for testing the speech discrimination abilities of young children.

Phonemic analysis

The American English NU-CHIPS word lists were developed to have similar phonemes present in the majority of selected groups (or sets) of test items. However, when spoken in New Zealand English, these phonemes sound different from each other. For example, in one test set, the correct item is “dog”, with the four alternatives being “dog”, “ball”, “frog”, and “car”. In the Australian recording currently being used, “dog” sounds similar to the alternative “frog”. However, “dog” sounds completely different to the “ball” and “car” alternatives. In this example, the original recording in American English would have been designed to have the vowel phoneme in “dog” for all four alternatives.

This observed difference does not adhere to the original purpose of the NU-CHIPS. Furthermore, the NU-CHIPS word lists cannot simply be re-recorded by a native speaker of New Zealand English, as the test material may not function with New Zealand and Australian

accents as originally intended with an American accent. The development of a new word list appropriate for testing the auditory processing abilities of both New Zealand and Australian listeners of English is the most reasonable solution.

Aims

The purpose of the current study is to develop a new four-alternative forced choice test that is appropriate for testing both New Zealand and Australian listeners of English for APD. An analysis of the phonetic distribution of the NU-CHIPS word lists will reveal the nature of the distribution of phonemes.

There is currently no appropriate four-alternative forced choice adaptive speech test available for testing New Zealand and Australian populations for APD. The stimuli presently available for the UCAST-FW, the NU-CHIPS word lists, are American English speech stimuli. It is anticipated that the development of a word list appropriate for New Zealand and Australian listeners of English will improve the sensitivity and specificity of the UCAST-FW when testing these populations for APD, and make further progress towards the future goal of widespread release of the UCAST-FW in New Zealand and Australian audiology clinics.

CHAPTER TWO

METHODS

Methods overview

A new word list was developed for the current project. The new stimuli were developed so that they would be more appropriate for use when testing New Zealand and Australian children with suspected auditory processing difficulties. The current stimuli used with the UCAST platform, the NU-CHIPS word lists, have been determined to not adhere to their original purpose intended by its developers when tested with New Zealand populations. The new word list will replace the NU-CHIPS word lists for use with the UCAST-FW. It is anticipated that utilisation of new word list with the UCAST-FW will lead to improved assessment of auditory processing difficulties in New Zealand and Australian children.

The current project is divided into several phases of development. Firstly, research was undertaken to establish the original rationale and methodology used by the developers of the original NU-CHIPS word lists. Following this, an analysis of the NU-CHIPS word lists was undertaken to determine the phonetic distribution of the target words, which was then compared to the phonetic distribution of the target words of the new word list.

Secondly, several steps were taken to develop the new word lists. This process included selecting target words and generating foils according to a schema by utilising several spreadsheets developed by Dr Greg O'Beirne. These tools included a CVC generator and several spreadsheets designed to facilitate the development process. Finally, successive revisions of the test stimuli resulted in the production of a final word list.

Evaluation of NU-CHIPS words lists

The stated rationale of the NU-CHIPS word lists, as published, is authored by Lois L. Elliott and Debra R. Katz. Their research is documented in the article "Northwestern University Children's Perception of Speech (NU-CHIPS)", published in 1980. Their original purpose for developing the NU-CHIPS word lists was to develop a new test to be used by clinical audiologists that would: (1) Be appropriate for children and other patients having a language age as young as three years; (2) Be phonetically representative; (3) Utilise a picture pointing response; (4) Have tape recordings available; (5) Provide equivalent forms so that multiple tests could be administered to a patient; and (6) Permit flexibility in clinical administration (Elliott & Katz, 1980).

Development of original NU-CHIPS test stimuli

Design of project

An earlier article authored by Elliott and colleagues (Elliott et al., 1979) documents the methodology used to select the stimuli for the NU-CHIPS. Stimuli were developed according to the rule that they must be within the receptive language skills of 3-year-old inner-city American children. It was assumed by the authors that words appropriate for this particular age group would be highly familiar to older (5-year-old) children with normal intelligence. The stimuli selected were monosyllabic nouns sourced from various magazines; these chosen words also appeared often in several books designed for young children, providing some evidence that the words were familiar to young children. The design of the project was three-fold: (1) The chosen words had to be drawable; (2) The test stimuli had to be presented via tape recordings; and (3) Subjects had to use a picture-pointing response to test stimuli.

Analysis of the NU-CHIPS

Elliott and Katz produced word lists appropriate for testing speech discrimination abilities of young American children. The assembly of test items in the NU-CHIPS were designed for listeners of American English. As a result, their targets and foils were organised into sets according their phonetic similarity. When spoken in American English, these targets and foils sound phonetically very similar to each other, adhering to the original purpose of the test. Final consonant /r/ is more pronounced in American English, but not in New Zealand English (with the exception of certain regions in the South Island of New Zealand).

A phonemic analysis of each target word in Book A and Book B of the NU-CHIPS was performed. The purpose of this was to examine the phonetic distribution of the target words in the word lists, using a New Zealand English accent. The phonetic composition of each target word was assessed and recorded. This analysis is presented in Appendix B. For example, the target word “purse” was examined. An analysis of this word revealed that it consisted of the phonemes /p/, /3/, and /s/. This procedure was repeated for all target words in the NU-CHIPS word lists. Each phoneme, or element, of the targets words was evaluated. This consisted of the initial consonant, the vowel, and the final consonant of each of the target words, commonly referred to as CVC structure.

Findings are centred on the fact that the NU-CHIPS word lists were originally developed for the purpose of testing the speech discrimination ability of young listeners of American English. As previously mentioned, the target words and foils within a given set of the NU-CHIPS interact differently according to accent. Each set of four alternatives were

chosen so that the target word in each set shared similar phonemes as the foils. This does not apply to New Zealand or Australian English accents.

The next course of action involved deciding if replacing certain words in the NU-CHIPS word lists would suffice, or if an entirely new set of word lists warranted development. It was decided that there was a need for completely new word lists to be developed. Reasons behind this decision were: (1) Being able to select words that enable an error analysis to be performed; (2) Being able to select words that adhere to a specific phonetic structure (i.e. CVC); (3) Copyright issues regarding altering the NU-CHIPS; and (4) To overall generate an entirely new set of word lists that are tailored to New Zealand and Australian populations.

Another aspect that needed consideration was the accent differences between New Zealand and Australian English. Although similar, there are significant differences that could potentially alter the way the new word lists would function if these accent differences were not accounted for. Certain phoneme combinations have different sounds when spoken in Australian English compared to New Zealand English. This was an important consideration when choosing foils to accompany each target word.

Development of new test material

Selection of target words

The current study aimed to adhere to the main principles originally used by the authors of the NU-CHIPS word lists. As previously mentioned, these principles, or constraints, consisted of using only drawable monosyllabic words, and words that were within the receptive language of children as young as three years old. In addition to these

criteria, the current study also added another criterion: the stimuli must adhere strictly to CVC structure. This is in contrast to the words in the NU-CHIPS, which consisted of CVC, CCVC, CV, and CVCC structures. In view of the somewhat challenging process faced by the NU-CHIPS authors of selecting test items that were drawable monosyllabic nouns, within the receptive vocabulary of 3-year-old children, and represented all phonemes (with the exception of initial /r/), the addition of another constraint was predicted to make the selection of new test stimuli challenging.

Potential target words that met the previously described criteria were initially sourced from existing word lists appropriate for testing young children. These lists were: the Word Intelligibility by Picture Identification (Ross & Lerman, 1970), Northwestern University Auditory Test No. 6 (Tillman & Carhart, 1966), CID Auditory Test W-22 (Hirsh et al., 1952), Kendall Toy Test (Kendall, 1953), and the NU-CHIPS. In addition to these sources, an online CVC generator (http://www.wordlistgenerator.net/) was also used to select potential target words that were drawable, and suitable for young children.

Several selected words that were not CVC structure in New Zealand English were among this initial list of target words. These were words that adhered to CVC structure when spoken in American English, but not when spoken in New Zealand or Australian English. Selected target words that contained final consonant /r/ follow: “car”, “door”, “jar”, “bar”, “bear”, and “chair”. Furthermore, target words “cow”, and “key” look like CVC words when written, but not when spoken. When spoken, “cow” and “key” adhere to CV structure. These target words were changed to CVC structure by the addition of final consonant /z/, changing them into plurals. A potential drawback with this modification was confusing participants when these particular words were represented pictorially.

As previously mentioned, there is a marked decrease in phonetic similarity between NU-CHIPS test and foil items when spoken in New Zealand English or Australian English. Furthermore, when spoken in American English, words such as “door” and “car” adhere to CVC structure, but not in New Zealand English. When spoken in New Zealand English, “door” and “car” are CV structure, as /r/ is blended with the vowel to form a diphthong - a blend of two vowels within the same syllable, where the sound begins with one vowel and glides towards the other (Shames & Anderson, 2002).

In addition, an extra list of CCVC format words was compiled along with the primary list of CVC words for future use if CVC format did not produce a substantial number of target words. Furthermore, words were also chosen to be appropriate for children as young as three years old, but this was not a specific criterion as words that lay outside this age were also included. As will be described in a later section, this minimum age requirement does not apply to the final version of our word list, which must be in the receptive vocabulary of children as least five years of age. The initial list of 163 CVC target words and 35 CCVC words are displayed below in Table 2 and Table 3, respectively.

Table 2
First List of CVC Target Words

bag	book	chin	fan	head	jug	log	nut	pup	seal	vet
ball	bud	coat	farm	hem	juice	man	pad	purse	sheep	vine
bar	bug	comb	fig	hen	key	map	page	rag	shirt	web
bat	bun	cot	fin	hog	kid	mat	pan	rain	soap	well
bath	bus	cow	fish	hole	king	meat	pearl	ram	soup	wheat
bear	cake	cub	fog	home	king	men	peg	rat	sun	wheel
bed	can	cup	food	horse	kite	moon	pen	rib	tag	wig
bees	cap	dad	foot	house	knees	mop	pet	ring	tape	wire
bell	car	dam	fork	hug	knife	mouse	phone	road	teeth	witch
bib	card	dart	girl	hut	knit	mouth	pig	rod	thumb	wood
bike	cat	dog	goose	jail	leg	mug	pin	room	tin	wool
bin	chain	doll	gum	jam	lid	mum	pit	rose	tongue	yard
bird	chair	door	gun	jar	light	nap	pole	rug	tool	zip
boat	cheek	dot	ham	jet	lip	net	pool	sad	tub	
bone	chief	duck	hat	judge	loaf	nose	pot	sail	van	

Table 3
List of CCVC Words

bread	club	flag	plug	skip	snake	train
clam	crab	frog	plum	sled	spoon	tram
clip	crib	fruit	school	slide	step	trap
clock	dress	glove	skid	slug	stove	truck
clown	drum	grape	skin	smile	swim	twig

Development of a schema

As previously mentioned, the new word lists would adhere to a four-alternative, forced choice format, consisting of one target word (correct choice) and three foils (incorrect choices). Following the selection of the initial list of target words, there was a need for a systematic way to generate foils for each target word. As each target word selected was of CVC structure, it was necessary, for consistency, for each foil to have this same structure. For this reason, all CCVC words were discarded.

A schema needed to be developed for the purpose of selecting appropriate foils for each target word. This process involved liaising with linguistics experts (Associate Professor Margaret Maclagan and Linguistics PhD student Mrs Jacqui Nokes) and Dr. Greg O'Beirne for input and guidance. From these meetings, it was established that certain phoneme combinations needed to be avoided when generating foils for the target words. More specifically, certain phoneme substitutions were disallowed based on their likelihood to alter other phonetic components, particularly the length of the vowel. For example, the vowel in "cap" is significantly lengthened in "cab", as the voicing of the substituted final consonant /b/ was not kept constant. This was an important consideration as vowel length inconsistencies across sets of targets and foils could potentially change the way the stimuli were originally intended to function, according to the schema. These guidelines, to be interpreted with respect to CVC structured words, are listed below:

- Final position consonants have a greater impact on the preceding vowel length than initial position consonants;
- When substituting final consonants, the manner of articulation should remain the same, as the length of the vowel can be altered;
- When substituting final consonants, the voicing should remain the same, as the length of the vowel can be altered; and,
- Avoidance of using words with final and initial consonant /l/, initial consonant /r/, initial consonant /j/, and initial consonant /w/.

Simply stated, the manner of articulation refers to how speech sounds are classified in terms of their use in the speech system, generally with respect to the release of air. The seven recognised categories of manner in New Zealand English follow: plosives, fricatives,

affricates, nasals, lateral, frictionless continuant and semi-vowels. Voicing refers to vibration of the vocal cords, which are a membranous structure located within the larynx. Sounds which are made with vocal fold vibration are voiced, while sounds made without vocal fold vibration are voiceless. To summarise, Table 4 displays the manner of articulation, voicing, and the corresponding phonetic symbols for consonants of New Zealand English.

The exclusion of final and initial consonant /l/, and initial consonants /r/, /w/ and /j/ were recommended as they can alter the length of the vowel. Take for example the CVC word “ball”, which has /l/ as a final consonant. In New Zealand English, final consonant /l/ can have a notable backing, or retraction effect on the preceding vowel. In this example, the final consonant /l/ almost disappears, altering the vowel in “ball”. This has implications regarding choosing appropriate foils for a target word containing the same vowel. To avoid this effect, retaining the same vowel and consonant combination will keep the vowel unchanged. Using the same example of “ball”, an appropriate foil would be “hall”. In this example, only the initial consonant has been changed, while the vowel and final consonant are retained.

An example to illustrate the substitution of a final consonant to generate foils, without altering the length of the vowel, is given for the word “cup”: “cut”, “cuk”. Although “cuk” is a nonsense word, it adheres to the guidelines previously described above. That is, the substitutions of the phonemes /t/ and /k/ are both voiceless plosives, as is the final consonant /p/ in the original word “cup”.

Table 4
Consonant Manner of Articulation, Voicing, and Phonetic Symbols of New Zealand English

Consonants			
Manner	**Symbol**	**Voicing**	**Word example**
Plosives	p	Voiceless	*p*at
	b	Voiced	*b*at
	t	Voiceless	*t*art
	d	Voiced	*d*art
	k	Voiceless	*c*ard
	g	Voiced	*g*uard
Fricatives	f	Voiceless	*f*an
	v	Voiced	*v*an
	θ	Voiceless	*th*in
	ð	Voiced	*th*en
	s	Voiceless	*s*eal
	z	Voiced	*z*eal
	ʃ	Voiceless	*sh*in
	ʒ	Voiced	lei*s*ure
	h	Voiceless	*h*ead
Affricates	tʃ	Voiceless	*ch*in
	dʒ	Voiced	*g*in
Nasals	m	Voiced	*m*ad
	n	Voiced	*n*od
	ŋ	Voiced	so*ng*
Approximants			
Lateral	l	Voiced	*l*ead
Frictionless continuant	r	Voiced	*r*od
Semi-vowels	w	Voiced	*w*ad
	j	Voiced	*y*ard

By taking the previously discussed phonetic guidelines into consideration, a schema was developed. The schema consisted of the following rules for selecting foils for a given target word:

- At least one of the three foils must share a vowel with the target;
- At least one of the three foils must share either the initial or final consonant with the target;

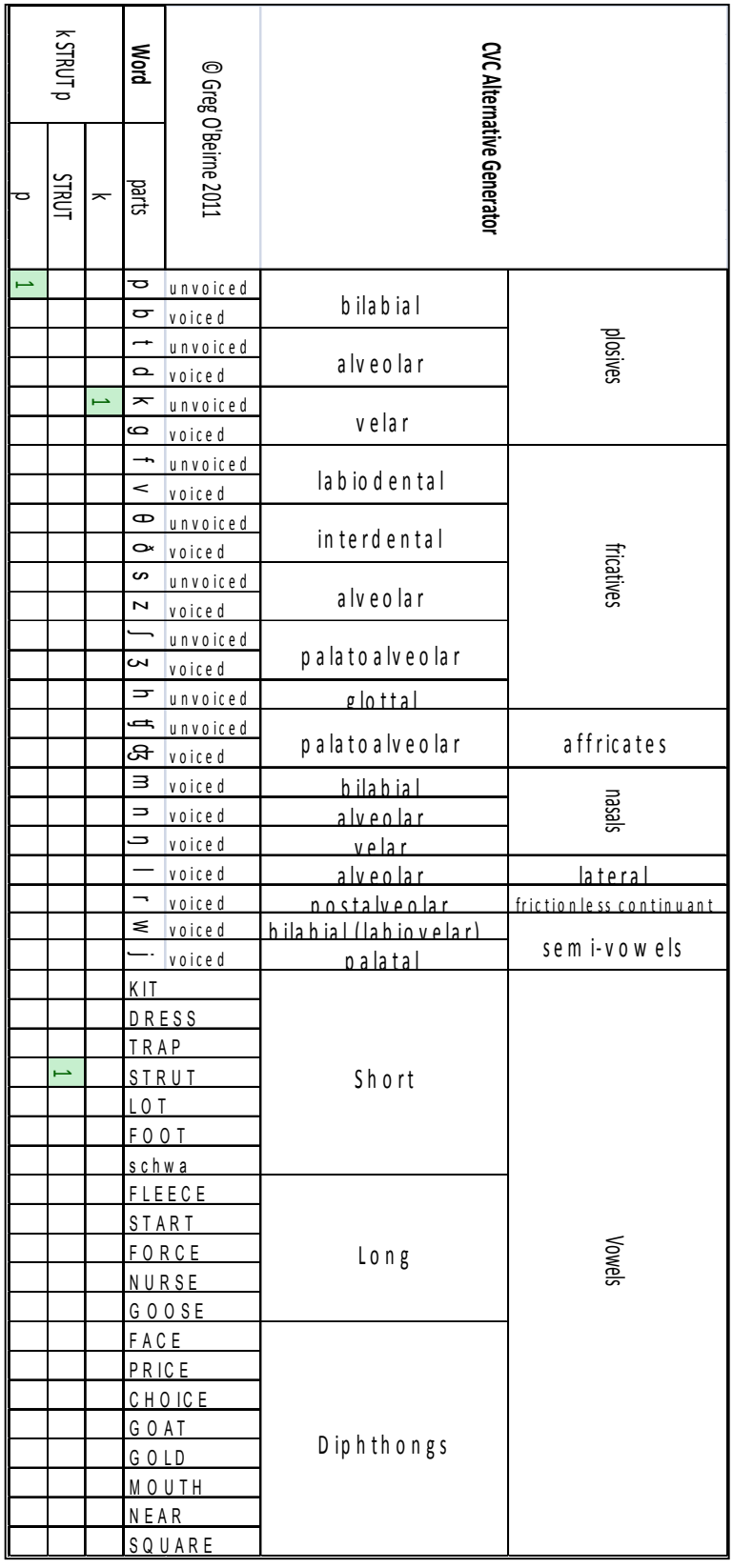
- One of the three foils must be completely phonetically unrelated to the target;
    - 50% of these foils must also be phonetically and semantically unrelated to the target; and,
    - The remaining 50% must be semantically related to the target.

The schema was developed so that as many components of the target word were distributed amongst the foils as possible. This was also a strategy used by the authors of the NU-CHIPS, who purposely chose foils that were phonetically similar to the target words.

Generation of CVC foil alternatives

An efficient way of generating CVC foils for each target word was needed. A Microsoft Excel spreadsheet was developed for this purpose by Dr Greg O'Beirne. This spreadsheet consisted of two main areas of operation: entry of each component of the target CVC word into appropriate sections, and the subsequent generation of other CVC words generated by substitutions performed according to a number of different rules. In the entry section of the spreadsheet, components of target CVC words were entered into cells according their individual characteristics. All phonemes of New Zealand English were represented. Each consonant was categorised according to manner of articulation, place of articulation and voicing. Similarly, all vowels were categorised according to vowel length (short and long) and diphthongs. Figure 2 below is a screen shot of the entry section of the spreadsheet. It shows how the CVC word "cup" was entered. Each component of the word is represented by the number 1, which is entered by the user in the appropriate box.

Figure 2
CVC Alternative Generator Entry Section



k STRUT p			Word	© Greg O'Beirne 2011	CVC Alternative Generator	
p	STRUT	k	parts			
1			p	unvoiced	bilabial	plosives
			b	voiced		
			t	unvoiced	alveolar	
			d	voiced		
		1	k	unvoiced	velar	
			g	voiced		
			f	unvoiced	labiodental	fricatives
			v	voiced		
			θ	unvoiced	interdental	
			ð	voiced		
			s	unvoiced	alveolar	
			z	voiced		
			ʃ	unvoiced	palatoalveolar	
			ʒ	voiced		
			h	unvoiced	glottal	
			ʧ	unvoiced	palatoalveolar	affricates
			ʤ	voiced		
			m	voiced	bilabial	nasals
			n	voiced	alveolar	
			ŋ	voiced	velar	
			l	voiced	alveolar	lateral
			r	voiced	postalveolar	frictionless continuant
			w	voiced	bilabial (labiovelar)	semi-vowels
			j	voiced	palatal	
			KIT		Short	Vowels
			DRESS			
			TRAP			
	1		STRUT			
			LOT			
			FOOT			
			schwa			
			FLEECE		Long	
			START			
			FORCE			
			NURSE			
			GOOSE			
			FACE		Diphthongs	
			PRICE			
			CHOICE			
			GOAT			
			GOLD			
			MOUTH			
			NEAR			
			SQUARE			

Following entry of the target CVC words into the spreadsheet, potential foils were generated according to nine different rules. These rules were more specific extensions of the previously described manner of articulation and voicing guidelines. Here, manner of articulation is referred to as class. These nine rules follow:

1. Replace first element with any consonant except /l/, /r/, /w/, or /j/;
2. Replace second element with elements from the same class, retaining voicing;
3. Replace third element with elements from the same class, retaining voicing;
4. Replace all three elements with different elements from the same class, retaining voicing;
5. Replace first element with any consonant of same voicing except /l/, /r/, /w/, or /j/;
6. Keep first element, replace other elements with elements from same class, retaining voicing;
7. Keep vowels, replace other elements with elements from same class, retaining voicing;
8. Keep third element, replace other elements with elements from the same class, retaining voicing; and,
9. Replace first element with elements from same class, retaining voicing

Figure 3 below presents a screen shot of this part of the spreadsheet to illustrate the generation of alternatives (potential foils) for the target word “cup”.

Figure 3

Generation of CVC Alternatives for Target Word "cup"

Rule 1:	Replace first element with any consonant except l, r, w, or j	
p STRUT p	b STRUT p	t STRUT p
d STRUT p	~~k STRUT p~~	g STRUT p
f STRUT p	v STRUT p	θ STRUT p
ð STRUT p	s STRUT p	z STRUT p
ʃ STRUT p	ʒ STRUT p	h STRUT p
ʧ STRUT p	ʤ STRUT p	m STRUT p
n STRUT p	ŋ STRUT p	

Rule 2:	Replace second element with elements from same class, retaining voicing	
k KIT p	k DRESS p	k TRAP p
~~k STRUT p~~	k LOT p	k FOOT p
k schwa p		

Rule 3:	Replace third element with elements from same class, retaining voicing	
~~k STRUT p~~	k STRUT t	k STRUT k

Rule 4:	Replace all three elements with different elements from same class, retaining voicing	
p KIT t	t KIT t	p DRESS t
t DRESS t	p TRAP t	t TRAP t
p LOT t	t LOT t	p FOOT t
t FOOT t	p schwa t	t schwa t
p KIT k	t KIT k	p DRESS k

Rule 5:	Replace first element with any consonant of same voicing except l, r, w, or j	
p STRUT p	t STRUT p	~~k STRUT p~~
f STRUT p	θ STRUT p	s STRUT p
ʃ STRUT p	h STRUT p	ʧ STRUT p

Rule 6:	Keep first element, replace other elements with elements from same class, retaining voicing	
k KIT p	k DRESS p	k TRAP p
~~k STRUT p~~	k LOT p	k FOOT p
k schwa p	k KIT t	k DRESS t
k TRAP t	k STRUT t	k LOT t
k FOOT t	k schwa t	k KIT k

Rule 7:	Keep vowels, replace other elements with elements from same class, retaining voicing	
p STRUT p	t STRUT p	~~k STRUT p~~
p STRUT t	t STRUT t	k STRUT t
p STRUT k	t STRUT k	k STRUT k

Rule 8:	Keep third element, replace other elements with elements from same class, retaining voicing	
p KIT p	t KIT p	k KIT p
p DRESS p	t DRESS p	k DRESS p
p TRAP p	t TRAP p	k TRAP p
p STRUT p	t STRUT p	~~k STRUT p~~
p LOT p	t LOT p	k LOT p

Rule 9:	Replace first element with elements from same class, retaining voicing	
p STRUT p	t STRUT p	~~k STRUT p~~

Selection of foils

Many alternatives for a given target word can be generated utilising the CVC generator. However, the CVC alternative generator was not able to exclude nonsense words, and produced all possible combinations of CVC words according to the nine rules previously described. Another step was required to extract the actual words from the nonsense words. This was a subjective process; however word choices were reviewed to ensure consistency of word selection. This process involved entering each target word into the CVC alternative generator to generate potential foils, and the extraction of all real English words from each of the nine rules that were drawable and likely to be familiar to young children. The results of this process are presented in Appendix C.

From the reasons previously described about the effects of the consonants /l/, /r/, /w/, and /j/ on vowel length, target words beginning with these phonemes were initially excluded. However, these excluded target words were later included, and had potential foils for each generated accordingly. This was because some could potentially be used, and followed consultation with Associate professor Margaret Maclagan. Furthermore, words that had final consonant /l/ were included, as well as CV structured words (with the addition of /z/ to change them to a CVC composition). In addition, three extra rules were added to the already existing nine. However, these did not require the use of the CVC alternative generator. Potential foils generated according to rules 10 to 12 were generated manually. These were:

10. Semantically related to the target;

11. Completely phonetically unrelated to the target; and,

12. Other (e.g. replace first element with /l/, /r/, /w/, or /j/

Final selection of foils

As previously mentioned, the new word list was to adhere to a four-alternative, forced choice format. This meant that only three foils for each target word were required. To achieve this, the nine rules used by the CVC alternative generator were grouped into three categories (one category for each foil), according to the schema rules. Figure 4 below presents this initial consolidation.

Figure 4
Consolidation of Generator Rules According to Schema

TARGET	FOIL 1			FOIL 2		FOIL 3	
	CVC Generator Rule 1	CVC Generator Rule 5	CVC Generator Rule 9	CVC Generator Rule 3	CVC Generator Rule 2	Rule 10	Rule 11
Target	Replace first element with any consonant except l, r, w, or j	Replace first element with any consonant of same voicing except l, r, w, or j	Replace first element with elements from same class, retaining voicing	Replace third element with elements from same class, retaining voicing	Replace second element with elements from same class, retaining voicing	Semantically related	Completely phonetically unrelated

As shown above in Figure 4, Foil 1 contains categories for potential foils relating to substitutions of the initial consonant of target words. Foil 2 contains categories for potential foils relating to substitutions of the vowel and final consonant of target words. Finally, Foil 3

contains categories for both semantically related and phonetically unrelated alternatives to target words. Rules 4, 6, 7 and 8 of the CVC alternative generator were grouped together in a category titled “surplus”. These were potential foils generated for the target words that did not meet the schema criteria, and were not utilised. Figure 5 below presents a screen shot of the surplus category.

Figure 5
Surplus CVC Alternatives

SURPLUS				
CVC Generator Rule 4	CVC Generator Rule 6	CVC Generator Rule 7	CVC Generator Rule 8	Rule 12
Replace all three elements with different elements from same class, retaining voicing	Keep first element, replace other elements with elements from same class, retaining voicing	Keep vowels, replace other elements with elements from same class, retaining voicing	Keep third element, replace other elements with elements from same class, retaining voicing	Other (e.g. replace first element with l, r, w, or j)

The next step involved selection of foils for each target word. Foils were chosen according to the rules. Where more than one possible foil satisfied the rule, a judgement was made about which was the most suitable. These judgements were based on ease of picture recognition, and appropriateness for young children. This was a subjective process; however, initial choices were reviewed regularly to ensure consistency of choices. To demonstrate this selection process, Figure 6 below displays the target word “fork”, and all possible alternatives generated according to each rule. Text highlighted in red indicates chosen words.

This process was repeated for all target words, including initially excluded words beginning with the consonants /l/, /r/, /w/, and /j/. Target words containing these initial consonants that survived the selection process were temporarily removed from the short list to a separate list to undergo linguistic verification by the associate supervisor of the current project. Target words that had unsuitable alternatives, or target words that did not satisfy the rules of each foil category, were excluded from the short list.

Figure 6
Example of Selection Process Using Target Word "fork"

TARGET	FOIL 1			FOIL 2		FOIL 3	
	CVC Generator Rule 1	CVC Generator Rule 5	CVC Generator Rule 9	CVC Generator Rule 3	CVC Generator Rule 2	Rule 10	Rule 11
Target	Replace first element with any consonant except l, r, w, or j	Replace first element with any consonant of same voicing except l, r, w, or j	Replace first element with elements from same class, retaining voicing	Replace third element with elements from same class, retaining voicing	Replace second element with elements from same class, retaining voicing	Semantically related	Completely phonetically unrelated
fork	cork, pork, chalk	pork, cork, chalk	hawk	fort		knife	gum

The short list consisted of 57 target words, and three associated foils for each target. The target words that made the short list are displayed below in Table 5. The short list also includes target words that survived the linguistic verification process which were initially excluded due to beginning consonant constraints. Comments were made next to test items which could potentially be problematic. These comments related to test items that were: too uncommon for children to identify, contained /l/, /r/, /w/, or /j/, plurals, or items that were too hard to be easily represented by a picture.

It is worth noting that, in an effort to increase the number of target words, additional CVC target words were included during the selection process. Not all of these additions

made the short list. Furthermore, all target words which were changed to plurals by the addition of /z/ as a final consonant (“car”, “door”, “cow”, “key”, “jar”, “bar”, “bear”, and “chair”) did not make the short this. Consultation with Jacqui Nokes revealed that only the word “keys” was the most appropriate, as it occurred naturally in plural form and would be less confusing to identify when represented by a picture.

Table 5
Short List of Target Words

bike	fork	chalk	tape	rock	cat
man	duck	shark	cone	card	sword
pan	kite	bug	dad	bat	lip
bird	bag	road	dart	knit	fern
mouse	bed	lock	cheek	rag	log
toes	feet	heart	night	ship	leaf
boat	gate	hook	nurse	coat	chip
rat	harp	peach	cot	suit	
ball	knot	rug	leg	comb	
fin	pig	hen	head	sock	

Selection of additional target words

The short list of target words was a marked decrease in number compared to the original list of 163 CVC target words presented previously in Table 2. There was a need to increase the number of target words so that the lists, and ultimately the test they are to be used with, lasts for a substantially longer amount of time. The short list, containing 57 “quads” (each quad consisting of one target word and three foils) was evaluated and a decision was made to select one foil from each quad to be used as a second target. That is, each quad now contained two target words, and two foils. Where one target is used in a

given quad, three foils are still present. The same applies for when the second target is used. This adheres to the four-alternative, forced choice format.

In addition, Foil 3 was modified. Previously, either a semantically related or phonetically unrelated word was assigned to each target word. Given that each set of quad contains two targets, it was necessary to choose only one word that shared both a semantic and phonetically unrelated relationship to the targets. A screen shot of the original target "ball", the selection of the second target "hall", re-structuring of Foil 3, and associated comment is presented below in Figure 7.

Figure 7
Selection of a Second Target (marked by an "x") From the First Two Foils

TARGET	2nd target?	FOIL 1	2nd target?	FOIL 2	FOIL 3		Comments?
		Replace initial consonant, keep V and C		Same initial consonant, replace V and/or C	Semantically related to 1st target, phonetically unrelated to 2nd target	Semantically related to 2nd target, phonetically unrelated to 1st target	
ball	x	hall		bell		house	*Ball could be an acceptable target re: final consonant /l/*

Organisation of test material

Colour-coding and establishment of relationships

All quads from the short list were retained, except for "tape", "hook", and "fern". These words were excluded as they were deemed too uncommon for young children to recognise both by picture and by sound. The word "shirt" and its foils from the original list of target words (listed in Table 2) were added, bringing the quads to a total of 55.

To clearly define these new relationships, sets of quads were colour-coded. New targets were classified as “Target 1” and “Target 2”. Quads containing Target 1 and Target 2 were coloured Green and Pink, respectively. Pink target also functioned as a foil, involving phoneme substitutions when not a target. A White coloured foil contained phoneme substitutions regarding either Target 1 or Target 2. The Last foil contained a semantically related relationship to the first target, and a phonetically unrelated relationship to the second target. In both cases, the Last foil was completely phonetically unrelated to both targets. This new colour-coding of quads, showing three quads to illustrate, are presented below in Figure 8.

Figure 8
Green Targets and Foils

Green Target	Pink Target or White Foil		Last Foil
	Replace initial consonant, keep V, C (pink = 2nd target)	Keep initial consonant, replace V and/or C (pink = 2nd target)	Semantically related to coloured target, phonetically unrelated to the other target
bat	hat	back	ball
boat	goat	bait	sail
card	guard	cord	page

Figure 8 shows this arrangement for quads with Target 1 (Green) functioning as the target word. As previously mentioned, Target 2 (Pink) also functioned as a target.

Production of foils for Pink targets required the following steps: (1) Green targets were simply moved to the previous position the Pink targets held; (2) Last foils remained in the same position; and (3) different White foils were chosen according to the criterion: "Keep initial consonant, replace V and/or final consonant (Green = 2nd target)". Figure 9 below shows the arrangement when Target 2 (Pink) is functioning as the target, with a different foil arrangement. This arrangement brought the total number of quads to 110, effectively doubling the number of quads by assigning a second target.

Figure 9
Pink Targets and Foils

Pink Target	Green Target or White Foil		Last Foil
	Replace initial consonant, keep V, C (green = 2nd target)	Keep initial consonant, replace V and/or C (green = 2nd target)	Semantically related to coloured target, phonetically unrelated to the other target
hat	bat	hut	ball
goat	boat	gate	sail
guard	card	gold	page

In addition to colour-coding the quads, the phonetic relationships between target words and foils were described. Shared elements (INITIAL C, V, FINAL C, SEMANTIC, UNRELATED) were recorded for each of the 110 quads. Duplications of quads were removed. Relationships were described according to the following categories:

- Relationship of Green target to Pink target;
- Relationship of Green target to White foil;
- Relationship of Pink target to White foil;
- Relationship of Green target to Last foil;
- Relationship of Pink target to Last foil; and,
- Relationship of White foil to Last foil.

Figure 10 below shows a screen shot to illustrate how these relationships were recorded for the first seven Green Targets.

Figure 10

Relationships of Quads

Green Target	Pink Target or White Foil: Replace initial consonant, keep V, C (pink = 2nd target)	Pink Target or White Foil: initial consonant, replace V and/or C (pink = 2nd target)	Last Foil: Semantically related to coloured target, phonetically unrelated to the other target	Green Target, Pink Target	Relationship	Green Target, White Foil	Relationship	Pink Target, White Foil	Relationship	Green Target, Last Foil	Relationship	Pink Target, Last Foil	Relationship	White Foil, Last Foil	Relationship
bat	hat	back	ball	bat + hat:	V, FINAL C	bat + back:	INITIAL C, V	hat + back:	V	bat + ball:	SEMANTIC, INITIAL C	hat + ball:	UNRELATED	back + ball:	INITIAL C
boat	goat	bait	sail	boat + goat:	V, FINAL C	boat + bait:	INITIAL C, FINAL C, SEMANTIC	goat + bait:	FINAL C	boat + sail:	SEMANTIC	goat + sail:	UNRELATED	bait + sail:	V
card	guard	cord	page	card + guard:	V, FINAL C	card + cord:	INITIAL C, FINAL C	guard + cord:	FINAL C	card + page:	SEMANTIC	guard + page:	UNRELATED	cord + page:	UNRELATED
chalk	fork	cheek	pen	chalk + fork:	V, FINAL C	chalk + cheek:	INITIAL C, FINAL C	fork + cheek:	FINAL C	chalk + pen:	SEMANTIC	fork + pen:	UNRELATED	cheek + pen:	UNRELATED
cheek	beak	chalk	head	cheek + beak:	V, FINAL C, SEMANTIC	cheek + chalk:	INITIAL C, FINAL C	beak + chalk:	FINAL C	cheek + head:	SEMANTIC	beak + head:	UNRELATED	chalk + head:	UNRELATED
dad	sad	dead	mum	dad + sad:	V, FINAL C	dad + dead:	INITIAL C, FINAL C	sad + dead:	FINAL C	dad + mum:	SEMANTIC	sad + mum:	UNRELATED	dead + mum:	UNRELATED
feet	meat	fort	shoes	feet + meat:	V, FINAL C	feet + fort:	INITIAL C, FINAL C	meat + fort:	FINAL C	feet + shoes:	SEMANTIC	meat + shoes:	UNRELATED	fort + shoes:	UNRELATED

Revision of test material

Organisation of quads according to phonetic composition

There was a need to re-organise the quads and their relationships in a clear and easy to understand format. This involved re-organisation of target words for particular sets of quads. In addition, the phonetic relationship between targets and each foil in all 106 quads were recorded. As there were deletions of quads due to duplications, the previous list was reduced to 106 quads. This revised list is displayed in Appendix D.

Foils from each set of quads were re-coloured. Previously coloured Green and Pink targets, White foils, and Last foils were changed to become colour-coded according to their specific phonetic relationship to target words. These relationships were:

- INITIAL C;
- FINAL C;
- INITIAL C, V;
- INITIAL C, FINAL C;
- V;
- V, FINAL C;
- SEMANTIC; and,
- UNRELATED.

Foils which had an unintentional semantic relationship with the target word were also identified. It was decided that foils with a semantic relationship to the target words (except for intended SEMANTIC foils) needed replacement. The purpose of this was to structure the new word list in a way that would enable an error analysis to be performed: using one

semantic foil based solely on that property, without any other relationship to the target word, would make participant errors clearer to identify.

In addition, targets and foils considered to be too difficult to draw, or had a concept that was too abstract for young children to understand, were highlighted in red. Items that only occurred once throughout the entire list were indicated by bold text. The revised list of targets and foils is displayed in Appendix E.

From this point, successive changes were made to the word list. These changes (in order) were as follows:

- Foils with unintentional SEMANTIC relationships to targets were replaced with already existing foils containing only phonetic relationships to targets;
- Foils with INITIAL C relationships were matched to targets with greater phonetic similarity (i.e. either “INITIAL C, V” or “INITIAL C, FINAL C”), effectively removing the INITIAL C relationship category from the word list;
- Test items representing abstract concepts were removed from the word list;
- Test items occurring only once in the word list (i.e. as a target or foil) were increased to occur at least twice;
- Quads containing foils that did not share at least one vowel with a target were swapped with at least one already existing foil that shared a vowel with the target, adhering to the schema;
- SEMANTIC and UNRELATED foils containing the same element(s) with targets were swapped with already existing completely phonetically unrelated SEMANTIC and UNRELATED foils, adhering to the schema;
- Each target was designed to occur as a foil at least once in the word list;

- All foils that did not also occur as targets were made targets, increasing the word list to 115 quads. Already existing foils were chosen according to the schema for additional targets; and,
- Targets were submitted to the ChildFreq resource (described below) for establishment of lexical norms.

Establishment of lexical norms

It was necessary to determine that all test items were familiar to young children before accepting the final version of the word list. This was to ensure that participants would not make errors based on their lack of knowledge of the test items. This was achieved by submitting all 115 target words to the ChildFreq resource (Bååth, 2010) to determine their suitability for testing young children. The ChildFreq resource is an online tool that utilises child language data taken from the CHILDES database, a freely available corpus of children's language containing transcriptions in over twenty languages. ChildFreq is a used to explore lexical norms of child language. That is, what words are understood and used at particular ages. It generated lexical norms of each of the test items for children from many English speaking countries, including New Zealand and Australia.

Each target word was submitted to ChildFreq and parameters were selected. Frequencies were ordered as a function of age (12-84 months) and not splitting the data by gender (no split sexes). Word occurrences per 1,000,000 words for children aged 12 months to 84 months were generated accordingly. A distribution of target word frequencies for ages 12 to 84 months, and all ages combined was performed. Based on this distribution, 17 targets (and subsequently their occurrences as foils) were removed from the word list. This was because these particular target words had word occurrences that were considered to

be unsatisfactory, and therefore unsuitable for testing young children. These eliminated words follow: “thief”, “robe”, “fin”, “bait”, “harp”, “dart”, “knit”, “leash”, “rag”, “toad”, “sheet”, “peg”, “fort”, “lip”, “cheek”, “guard”, and “fish”. The word “fish” was eliminated based on a lack of foil alternatives according to the schema, not based on its frequency of occurrence.

The final version of our word list (described in Table 7 of Chapter Three below) contained 98 quads in total, and met the following schema criteria:

- At least one of the three foils shared a vowel with the target;
- At least one of the three foils shared either the initial or final consonant with the target;
- One of the three foils was completely phonetically unrelated to the target;
    - 50% of these foils were both phonetically and semantically unrelated to the target; and,
    - The remaining 50% was both semantically related and phonetically unrelated to the target

Phonemic analysis

A phonetic distribution of the surviving 98 target words in the final list was performed. The purpose was to compare the phonetic distribution of target words in the NU-CHIPS with the target words in the new word list. It was anticipated that all phonemes would be represented in the new word list, with the exception of /w/, /j/, and /schwa/ due to previous exclusions. This analysis is presented in Appendix F.

CHAPTER THREE

RESULTS

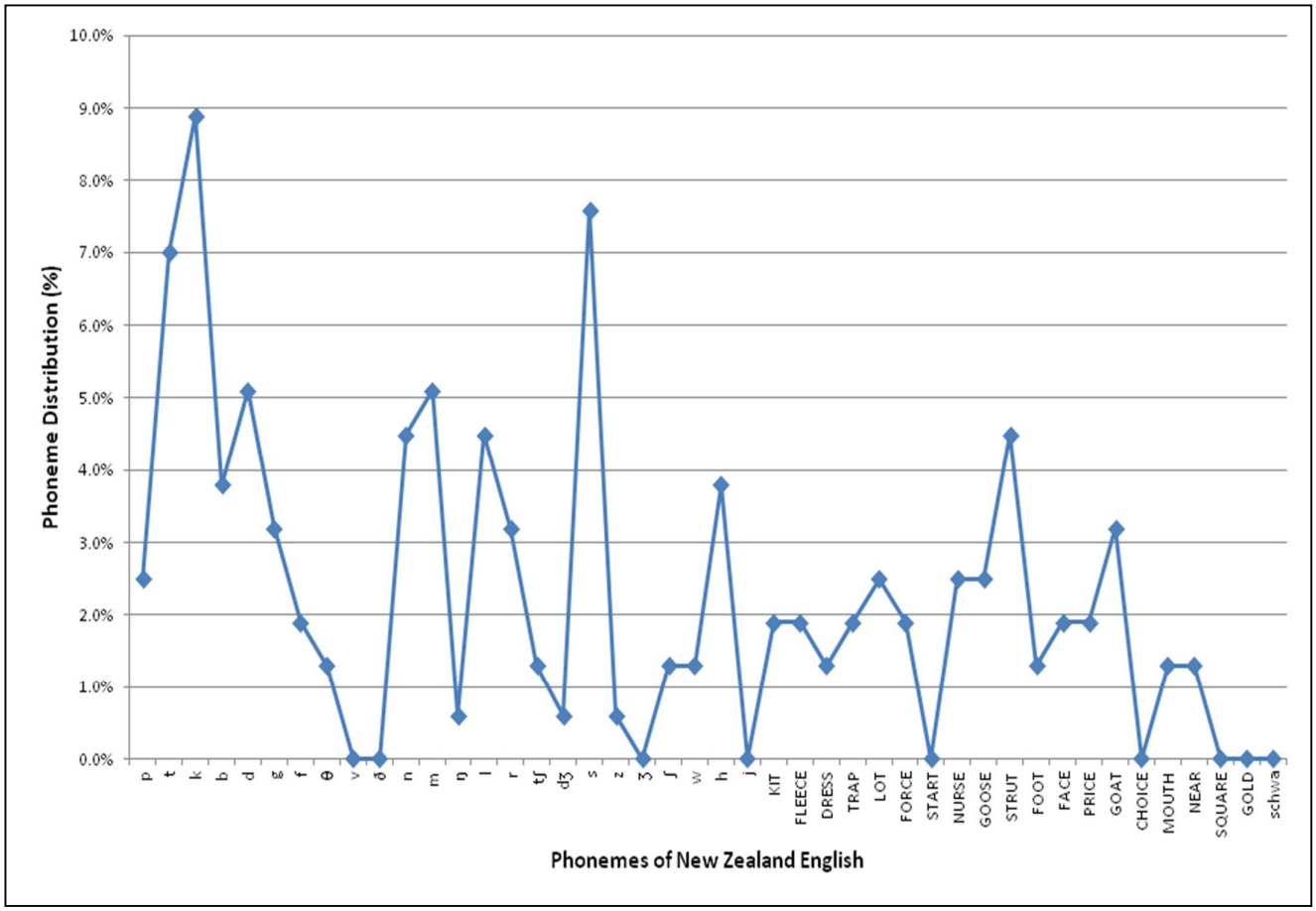
Results overview

The results from the development process of the word lists are presented in several sections. Section one presents the phonetic distribution of the NU-CHIPS word lists, the phonetic distribution of target words in the new word list, and a comparison of the phonetic distribution of the new word list targets to the targets in the NU-CHIPS word lists. Section two presents the number of occurrences of specific phonetic relationships to target words in the final version of the new word list. Section three presents the lexical norms for target words in the final version of the word list, and eliminated target words. Finally, section four presents the final version of the new word list.

Section One: Phonetic distribution and comparison of targets in NU-CHIPS and new word list

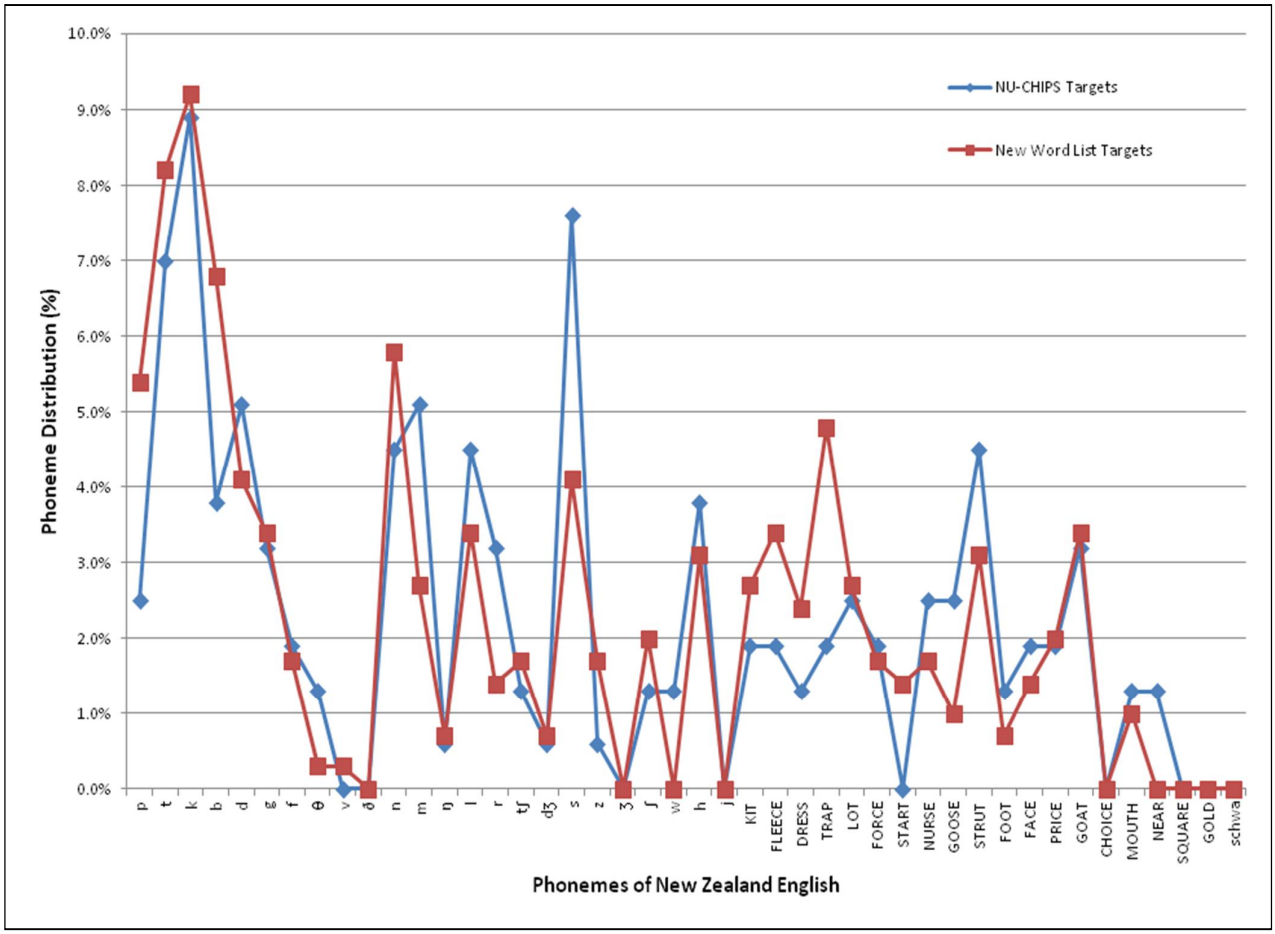
A phonemic analysis of each of the target words occurring in both Book A and Book B of the NU-CHIPS word lists was performed, using a New Zealand accent. It was necessary to establish the frequency of phoneme occurrences throughout the target words, to enable a direct comparison of the phonetic distribution of target words between the NU-CHIPS word lists and the new word list. Figure 11 below shows displays the phonetic distribution of NU-CHIPS target words according to their percentage of total occurrence throughout the list.

Figure 11
NU-CHIPS Targets Phoneme Distribution



Following the measurement of the phonetic distribution of the NU-CHIPS target words, a measurement of the phonetic distribution of the surviving 98 target words in the final list was performed and compared to the NU-CHIPS distribution. As each list had a different number of target words, percentage of occurrence was used to make direct comparisons between target words of both lists. This distribution is presented below in Figure 12.

Figure 12
NU-CHIPS Targets versus New Word List Targets



Both word lists have targets exhibiting a similar distribution of nasals (/m/, /n/, /ŋ/), affricates (/tʃ/, /dʒ/) and plosives (/p/, /b/, /t/, /d/, /k/, /g/). Overall, plosives from both groups yielded the highest percentage of phonemes. With the exception of /s/, the distribution of fricatives (/f/, /v/, /θ/, /ð/, /z/, /ʃ/, /ʒ/, /h/) yielded similar results. The consonant /s/ yielded the most significant percentage difference of all phonemes: 7.6% (NU-CHIPS) compared to 4.1% (new word list). The NU-CHIPS targets had an overall greater

percentage of approximants (/w/, /l/, /r/), with the exception of /j/, which had an occurrence of 0.0% for both word lists.

Vowels differed in phonetic distribution the most. On average, NU-CHIPS targets contained the greatest percentage of diphthongs (FACE, MOUTH, NEAR) when compared to the new word list targets. The new word list targets contained a greater distribution of short vowels when compared to the distribution of the NU-CHIPS targets (KIT, DRESS, TRAP). Remaining short vowels (FOOT, LOT, STRUT, schwa) had similar distribution percentages for both groups of targets.

Section Two: Analysis of phonetic relationships in new word list

An analysis of the occurrence of phonetic relationships in the new word list was performed. Table 6 below presents the percentages according occurrence of phonetic relationship categories.

Table 6
Distribution of Phonetic Relationship Categories of New Word List

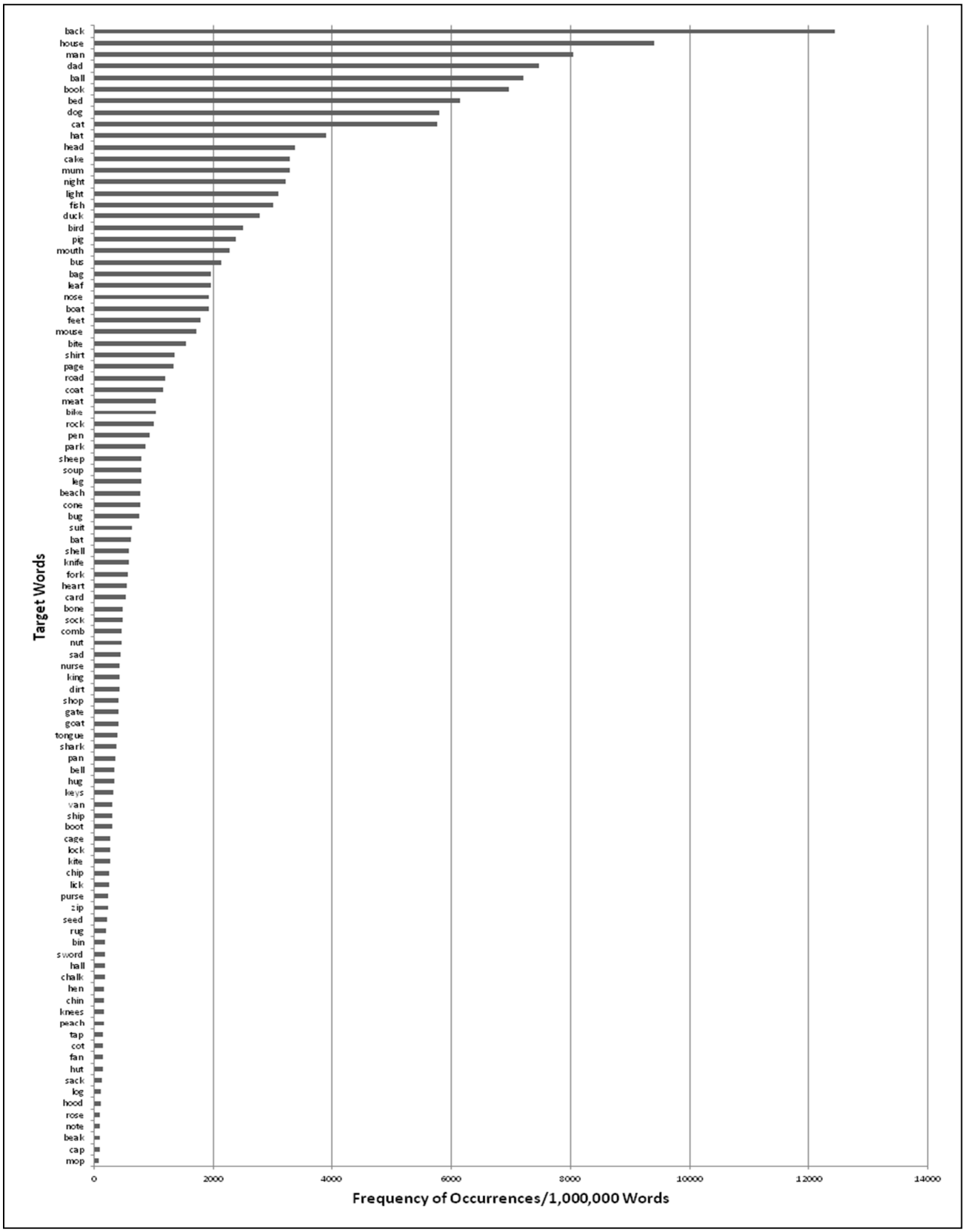
Category	Target and Foil 1	Target and Foil 2	Target and Foil 3
V, FINAL C	61%	0%	0%
V	37%	16%	0%
INITIAL C, V	2%	15%	0%
INITIAL C, FINAL C	0%	26%	0%
FINAL C	0%	43%	0%
SEMANTIC	0%	0%	50%
UNRELATED	0%	0%	50%

Table 6 shows these phonetic relationships with respect to targets and foils in each quad of the new word list. There was no particular desired distribution for the relationships; except for the SEMANTIC and UNRELATED foils, which adhered to the schema by each occurring throughout the list 50% of the time.

Section Three: Lexical norms of new word list targets

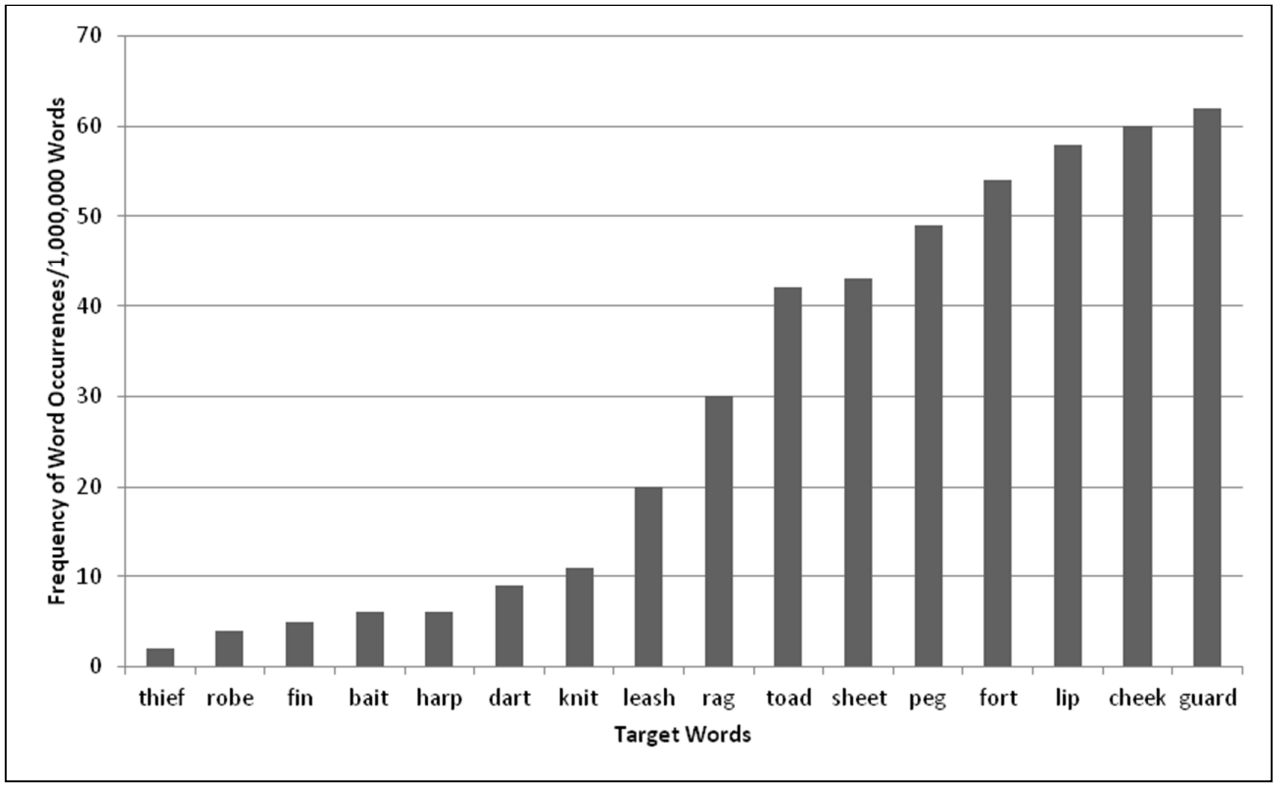
Surviving target words were submitted to the ChildFreq resource to generate lexical norms for each according to age. Word frequencies for ages 12 months through to 84 months were generated. Figure 13 below displays this distribution for the surviving 98 target words selected for the final version of the new word list. This is according to the grand totals of each age group with respect to each target word.

Figure 13
Lexical Norms of Targets from Final Version of Word List



This distribution shows that the target word with the lowest frequency was “mop”, occurring a total of 91 times. In contrast, target word “back” occurred significantly more than any other target word, occurring a total of 12436 times. Target words that did not have satisfactory word occurrences, and were therefore removed from the previous list of 115 targets, are presented below according to their frequencies in Figure 14. “Guard” was the cut-off point, occurring a total of 62 times.

Figure 14
Eliminated Target Words



Section Four: Final version of new word list

The final version of our word list, containing 98 quads and colour-coded foils according to phonetic relationships to targets, is presented below in Table 7. The mean number of occurrences of test items throughout the word list was 4. The lowest and highest numbers of occurrences were recorded at 2 and 8, respectively.

Table 7
Final Version of New Word List

#	Target	Foil 1	Foil 2	Foil 3		Target and Foil 1	Target and Foil 2	Target and Foil 3
1	nose	rose	keys	head		V, FINAL C	FINAL C	SEMANTIC
2	dad	sad	head	mum		V, FINAL C	FINAL C	SEMANTIC
3	purse	nurse	bus	bag		V, FINAL C	FINAL C	SEMANTIC
4	sock	rock	duck	boot		V, FINAL C	FINAL C	SEMANTIC
5	van	man	hen	bus		V, FINAL C	FINAL C	SEMANTIC
6	chalk	fork	duck	pen		V, FINAL C	FINAL C	SEMANTIC
7	zip	ship	shop	suit		V, FINAL C	FINAL C	SEMANTIC
8	shell	bell	hall	beach		V, FINAL C	FINAL C	SEMANTIC
9	boat	coat	kite	van		V, FINAL C	FINAL C	SEMANTIC
10	rose	nose	keys	leaf		V, FINAL C	FINAL C	SEMANTIC
11	hen	pen	pan	duck		V, FINAL C	FINAL C	SEMANTIC
12	goat	boat	cat	hen		V, FINAL C	FINAL C	SEMANTIC
13	head	bed	card	mouth		V, FINAL C	FINAL C	SEMANTIC
14	hall	ball	bell	tap		V, FINAL C	FINAL C	UNRELATED
15	mop	shop	chip	cake		V, FINAL C	FINAL C	UNRELATED
16	hug	bug	bag	sack		V, FINAL C	FINAL C	UNRELATED
17	rug	bug	pig	mop		V, FINAL C	FINAL C	UNRELATED
18	fan	van	pen	shark		V, FINAL C	FINAL C	UNRELATED
19	night	kite	coat	sock		V, FINAL C	FINAL C	UNRELATED
20	man	fan	pen	shark		V, FINAL C	FINAL C	UNRELATED
21	fork	chalk	back	shell		V, FINAL C	FINAL C	UNRELATED
22	rock	sock	fork	boot		V, FINAL C	FINAL C	UNRELATED
23	nurse	purse	bus	bag		V, FINAL C	FINAL C	UNRELATED
24	sad	dad	head	mum		V, FINAL C	FINAL C	UNRELATED
25	shirt	dirt	nut	bed		V, FINAL C	FINAL C	UNRELATED
26	kite	night	cot	ball		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
27	coat	note	kite	sock		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
28	nut	hut	night	seed		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
29	cat	hat	cot	dog		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
30	lock	sock	lick	knees		V, FINAL C	INITIAL C, FINAL C	UNRELATED
31	ball	hall	bell	house		V, FINAL C	INITIAL C, FINAL C	UNRELATED
32	bug	hug	bag	sack		V, FINAL C	INITIAL C, FINAL C	UNRELATED
33	log	dog	leg	chin		V, FINAL C	INITIAL C, FINAL C	UNRELATED
34	pan	man	pen	king		V, FINAL C	INITIAL C, FINAL C	UNRELATED
35	bell	shell	ball	mop		V, FINAL C	INITIAL C, FINAL C	UNRELATED
36	beach	peach	beak	shell		V, FINAL C	INITIAL C, V	SEMANTIC
37	chip	zip	chin	cake		V, FINAL C	INITIAL C, V	SEMANTIC
38	bat	hat	back	park		V, FINAL C	INITIAL C, V	SEMANTIC
39	cone	bone	comb	pig		V, FINAL C	INITIAL C, V	UNRELATED
40	bite	light	bike	cap		V, FINAL C	INITIAL C, V	UNRELATED

41	cage	page	cake	knees		V, FINAL C	INITIAL C, V	UNRELATED
42	mouse	house	mouth	tongue		V, FINAL C	INITIAL C, V	UNRELATED
43	suit	boot	soup	zip		V, FINAL C	INITIAL C, V	UNRELATED
44	shark	park	heart	goat		V, FINAL C	V	SEMANTIC
45	keys	knees	sheep	house		V, FINAL C	V	SEMANTIC
46	dog	log	rock	cat		V, FINAL C	V	SEMANTIC
47	note	boat	cone	book		V, FINAL C	V	SEMANTIC
48	page	cage	cake	book		V, FINAL C	V	SEMANTIC
49	house	mouse	mouth	gate		V, FINAL C	V	SEMANTIC
50	ship	chip	lick	beach		V, FINAL C	V	SEMANTIC
51	feet	meat	peach	pen		V, FINAL C	V	UNRELATED
52	boot	suit	soup	rose		V, FINAL C	V	UNRELATED
53	bed	head	hen	hat		V, FINAL C	V	UNRELATED
54	peach	beach	feet	shell		V, FINAL C	V	UNRELATED
55	bone	cone	comb	nut		V, FINAL C	V	UNRELATED
56	park	shark	heart	road		V, FINAL C	V	UNRELATED
57	light	bite	bike	mop		V, FINAL C	V	UNRELATED
58	hat	bat	back	ball		V, FINAL C	V	UNRELATED
59	tap	cap	cat	dog		V, FINAL C	V	UNRELATED
60	meat	feet	light	dad		V, FINAL C	FINAL C	UNRELATED
61	mum	hug	comb	lock		V	FINAL C	UNRELATED
62	leaf	beach	knife	road		V	FINAL C	UNRELATED
63	bus	duck	nurse	tap		V	FINAL C	UNRELATED
64	bin	ship	man	shark		V	FINAL C	UNRELATED
65	bag	dad	rug	meat		V	FINAL C	UNRELATED
66	dirt	purse	boat	nose		V	FINAL C	UNRELATED
67	hood	book	bird	note		V	FINAL C	UNRELATED
68	pig	bin	bug	hen		V	FINAL C	SEMANTIC
69	king	bin	tongue	man		V	FINAL C	SEMANTIC
70	card	heart	bird	page		V	FINAL C	SEMANTIC
71	heart	card	bite	nose		V	FINAL C	SEMANTIC
72	knees	leaf	keys	head		V	FINAL C	SEMANTIC
73	tongue	bug	king	mouth		V	FINAL C	SEMANTIC
74	beak	sheep	chalk	head		V	FINAL C	SEMANTIC
75	leg	pen	log	chin		V	INITIAL C, FINAL C	SEMANTIC
76	back	cap	bike	shirt		V	INITIAL C, FINAL C	SEMANTIC
77	pen	leg	pan	chalk		V	INITIAL C, FINAL C	SEMANTIC
78	book	hood	beak	page		V	INITIAL C, FINAL C	SEMANTIC
79	lick	chip	lock	tongue		V	INITIAL C, FINAL C	SEMANTIC
80	duck	bus	park	hen		V	INITIAL C, FINAL C	SEMANTIC
81	cot	rock	cat	bed		V	INITIAL C, FINAL C	SEMANTIC
82	sheep	meat	shop	goat		V	INITIAL C, FINAL C	SEMANTIC
83	seed	keys	sword	rose		V	INITIAL C, FINAL C	SEMANTIC
84	bird	nurse	bed	mouth		V	INITIAL C, FINAL C	UNRELATED

85	gate	cake	goat	fan		V	INITIAL C, FINAL C	UNRELATED
86	shop	sock	ship	bin		V	INITIAL C, FINAL C	UNRELATED
87	hut	mum	hat	king		V	INITIAL C, FINAL C	UNRELATED
88	sack	cat	sock	boot		V	INITIAL C, FINAL C	UNRELATED
89	sword	fork	sad	mum		V	INITIAL C, FINAL C	UNRELATED
90	knife	light	night	sword		V	INITIAL C, V	SEMANTIC
91	soup	boot	suit	peach		V	INITIAL C, V	SEMANTIC
92	chin	zip	chip	nose		V	INITIAL C, V	SEMANTIC
93	bike	light	bite	van		V	INITIAL C, V	SEMANTIC
94	mouth	house	mouse	tongue		V	INITIAL C, V	SEMANTIC
95	comb	bone	cone	pig		V	INITIAL C, V	UNRELATED
96	cap	bat	cat	dog		V	INITIAL C, V	UNRELATED
97	road	rose	sword	shirt		INITIAL C, V	FINAL C	UNRELATED
98	cake	cage	park	soup		INITIAL C, V	FINAL C	SEMANTIC

CHAPTER THREE

DISCUSSION

Discussion overview

The purpose of the current study was to develop a new word list designed specifically for testing New Zealand and Australian adults and children with suspected auditory processing difficulties. The UCAST platform is a computer-based adaptive speech test which has improved the sensitivity and efficiency of testing using low-pass filtered words, compared to other tests that use words presented at a constant level. It has proven to be a successful tool for the assessment of auditory processing skills in both children and adults (McGaffin, 2007; Sincock, 2008; Heidtke, 2010; Abu-Hijleh, 2011). Barriers to the widespread release of the UCAST-FW are two-fold: (1) The University of Canterbury Speech and Hearing Clinic does not own the NU-CHIPS stimuli the UCAST-FW utilises; and (2) The NU-CHIPS word lists are not appropriate for assessing the auditory processing skills of New Zealand and Australian populations. It was proposed that the new word list would yield more accurate representations of the auditory processing abilities of New Zealand and Australian adults and children.

Comparison of new word list to New Zealand and Australian English

The need for the development of a new four-alternative forced choice test was supported by observations made by previous studies testing New Zealand participants with the UCAST and the NU-CHIPS stimuli. McGaffin (2007) noted that some picture representations of the test stimuli may not have been appropriate for New Zealand children, and consequently used words in the place of pictures for testing purposes. In addition, Heidtke (2010) also noted the importance of using speech stimuli presented in a familiar accent and vocabulary, after testing New Zealand participants using an Australian

recording of the NU-CHIPs stimuli. These findings highlight the fact that the NU-CHIPS stimuli are not functioning well for both New Zealand and Australian accents.

The final version of the new word list contains words that are considered to be familiar to both New Zealand and Australian children. Words that were considered to be more familiar to countries other than New Zealand and Australia were excluded. For example, the word “moose” would be more familiar to North American children than New Zealand and Australian children. Such exclusions were made during the selection process of target words and the generation of foils.

The main consideration was choosing test items that functioned well for both Australia and New Zealand accents. Words that sound similar in a New Zealand accent can sound markedly different in an Australian accent. For example, the words “dole” and “doll” sound the same when spoken by a New Zealand speaker of English, but not with an Australian accent. For this reason, words in the new word list were examined with respect to their compatibility with both accents, and the schema. The new word list was considered to be a good test for both New Zealand and Australian listeners of English.

Comparison of NU-CHIPS and new word list: Age appropriateness

The current study aimed to develop a new word list suitable for testing young children. There were severe constraints imposed on the selection of test stimuli. Test items that were selected for the final version of the word list were drawable CVC monosyllables which adhered to a strict schema. This was considered to be a challenging task in its own right. It was not a specific aim of the current study to develop test items appropriate for

children as young as three years of age, in contrast to the goal achieved by the authors of the NU-CHIPS word lists.

The current study aimed to work within a 5-year-old language level. Reasoning behind this decision was primarily based on the age demographic the new word list was intended to be tested with. This particular demographic was children of an age deemed suitable for undergoing an APD assessment. Children who undergo an APD assessment are typically around ages six or seven years and older. As the APD test battery can be very lengthy, younger children are more susceptible to the effects of fatigue and loss of concentration than older children, which can make accurate interpretation of test results difficult. By choosing test items suitable for children with a receptive vocabulary as young as 5 years old, it increased the likelihood of older children having an even greater familiarity with the test items. This was predicted to reduce errors made due to unfamiliarity with the test material. Future testing with the UCAST-FW will reveal how children as young as 5 years old perform.

Comparison of NU-CHIPS and new word list: Structure

A comparison of test material revealed the NU-CHIPS word lists contained significantly more repetition of test items than the new word list. The materials developed for the NU-CHIPS consisted of four randomisations of the same 50 target words and foils. Although this produced a test that was highly familiar, results indicated that as many as four different randomisations of the test material were able to be administered within a single test session without the introduction of an improvement in performance attributable to learning or practice effects (Elliott & Katz, 1980). It would not be unreasonable to assume that the new word list would yield the same result, following testing children and adults with varying auditory processing ability.

A further comparison of the structure of the NU-CHIPS word lists to the new word list structure revealed the NU-CHIPS did not include designated semantic distracter items or phonetically unrelated distracter items for each set of four alternatives. The new word list included these distracters items because they contain absolutely no phonetic similarity to the target word. This would allow test administrators to observe whether participants were choosing these items based on semantic similarity to the target word only, as the semantic distracters also have no phonetic resemblance to the target. On the other hand, participants consistently selecting distracter items containing neither semantic nor phonetic similarity to the target should signal participant difficulties with the task. These types of distracters were included as they could reveal whether cognitive aspects of hearing played a significant role in the selection of test items.

Strengths of new word list

A benefit of developing an entirely new word list appropriate for New Zealand and Australian populations was selecting test items that would enable an error analysis to be performed. Performing an error analysis would reveal what errors are consistently being made by participants, if any. This meant that errors made by participants could be analysed more efficiently based on the types of confusions made. Specific relationships between foils and targets were established so that errors relating to initial consonants, final consonants, vowels, semantic and phonetically unrelated distracter items were able to be identified. As the UCAST-FW test is adaptive, incorrect responses adjust the low-pass filter setting so the stimulus is more intelligible. A child consistently choosing the semantically unrelated distracter foil, for example, could be interpreted as errors based on inattentiveness or genuine difficulties with processing the auditory stimuli.

Another benefit was the frequency test items occurred throughout the word list. The new word list was constructed with the intention of ensuring test items occurred more than once throughout the list, including as a target. The purpose of this was to make the word list a less difficult test to administer by including redundancy of test items. Earlier versions of the word list contained some test items that only occurred once throughout the list, either as a target word or a foil. By ensuring that each test item occurred more than once, it could decrease the likelihood of errors made based on unfamiliarity with test items. For example, a participant may discount a correct test item due to its lack of appearance in the word list, and choose a more familiar alternative instead.

Another benefit was the selection of test material that was more familiar to New Zealand and Australian children. The NU-CHIPS word lists contained words that were based on their level of familiarity in America rather than New Zealand (Elliott et al., 1979). Words such as “bear” and “snake” were considered to be words that young New Zealand children were not exposed as often as young American children. For this reason, all words presented in the new word list were considered to be appropriate for both New Zealand and Australian children.

Weaknesses of new word list

This study set an ambitious goal of selecting targets and foils that all worked within a strict schema. A weakness was allowing previously excluded test items into the final version of the word list. Certain phonemes were recommended to be excluded following consultation with linguistic experts. These phonemes were final and initial consonant /l/, and initial consonants /r/, /w/ and /j/. Words containing these phonemes could violate the schema, which required keeping the vowel of a target word the same for at least one foil

alternative in each quad. The current study aimed to avoid this as much as possible by initially excluding words containing these phonemes as they could potentially alter the way the stimuli were originally intended to function. However, some words containing these phonemes were included in the final version of the word list due limited foil alternatives that adhered to the schema.

A further weakness was the absence of an acoustic analysis of the new test stimuli. An acoustic analysis would reveal whether attempting to keep vowel lengths the same for particular targets and foils was successful. That is, to determine whether there were significant differences in vowel length between targets and foils for each quad in the final version of the word list. An acoustic analysis for the purpose of the current study would involve recording the test material using a New Zealand speaker and generating spectrograms of each test item of the new word list to graphically represent the frequency content of the speech signal.

Examining a spectrogram for vowel lengths would first involve identifying test items in each quad sharing the same vowel relationship. Graphically, vowel sounds are associated with dark, high-energy bands that follow an approximately horizontal path across the horizontal dimension of the spectrogram (Shames & Anderson, 2002). Vowel length is measured against time on the horizontal axis. The overall aim of performing an acoustic analysis would be to: (1) Provide further objective information regarding interactions between targets and foils when spoken; (2) Identify test items where significant differences between vowel lengths of targets and foils lay; and (3) Make adjustments to the word list where necessary, according to the information obtained by acoustic analysis.

Limitations and directions for future research

A limitation of the study was that the word frequencies of the test items in the final version of the word list were not generated specifically according to the lexical norms of New Zealand and Australian children. The ChildFreq resource was used to generate lexical norms of each of the test items for children from many English speaking countries, including New Zealand and Australia. Unfortunately, the parameter for selecting lexical norms according to specific countries was not available. However, ChildFreq was still considered a highly valuable tool for determining suitable test items for the final version of the word list.

The primary aim of the current study was to develop a new word list to test New Zealand and Australian populations with suspected auditory processing difficulties, and ultimately replace the NU-CHIPS word lists as the new UCAST-FW stimuli. This primary aim was achieved. The most logical direction for future development would involve several stages. Firstly, a recording of the new word lists using a native New Zealand speaker would be required. Secondly, an artist would need to be enlisted to prepare new drawings for each test item. Finally, the new recording of the word list would need to be normalised in order to use the UCAST-FW to gather normative data.

Gathering normative data would involve testing a large number of participants with varying levels of auditory processing ability with the UCAST platform and the new stimuli. Overall, the normalisation process should make the UCAST-FW a more effective test of the auditory processing abilities of both children and adults. Furthermore, a decision as to whether to use a male or female speaker for the new test stimuli would have to be made. The NU-CHIPS authors made recordings using both male and female speakers to present the test stimuli.

The new word list was designed primarily for New Zealand and Australian populations. However, the new word list could potentially apply to other English accents in the same way they apply to New Zealand and Australian accents. One group that was given consideration was the United Kingdom. The word list was examined with respect to familiarity of test items to adults and children from the United Kingdom. A preliminary judgement was made that all test items were familiar enough for adults and children from the United Kingdom to easily identify.

However, the extent to which the test items adhered to the schema when spoken by a speaker from the United Kingdom is significantly more important. This is a question that could be explored further if the UCAST-FW was to be released for use in audiology clinics outside New Zealand and Australia. This would broaden the applicability of the UCAST-FW and therefore make the new word lists an even more valuable tool as more clinical audiologists would be able to test children with suspected APD. Moreover, another area for future research would be to look at other English speaking countries. The new word lists may be able to apply to different English accents in the same way that they are appropriate for New Zealand and Australian listeners of English.

Clinical implications and conclusions

The goal of the current study was to develop a new four-alternative forced-choice word list for use with the UCAST-FW, a computerised adaptive filtered speech test. Further development and testing of the word list will lead to a final version appropriate for use, and subsequent release, of the UCAST-FW beyond the University of Canterbury Speech and Hearing Clinic. The release of the UCAST-FW has the potential to improve the efficiency of assessment of APD in the clinical setting when used in conjunction with the typical APD test

battery. This has implications regarding the inclusion of the UCAST-FW in future test batteries for the clinical assessment and diagnosis of APD.

APPENDICES

Appendix A

Final version of NU-CHIPS

Book A

01	dog	ball	frog	car
02	purse	shirt	girl	bird
03	fish	witch	milk	sink
04	boat	stove	coat	nose
05	hair	ham	hand	man
06	witch	watch	fish	frog
07	book	shoe	foot	food
08	light	knife	slide	smile
09	truck	cup	duck	tongue
10	school	shoe	food	spoon
11	door	dog	boy	fork
12	juice	mouth	horse	house
13	knife	slide	bike	light
14	tree	train	cake	grape
15	meat	tree	foot	teeth
16	grape	sink	cake	snake
17	stair	hand	bread	head
18	dress	duck	bus	book
19	car	clock	clown	truck
20	juice	spoon	shoe	school
21	chair	hair	bear	head
22	cup	truck	tongue	gun
23	watch	fish	sink	witch
24	meat	teeth	witch	milk
25	gum	duck	tongue	gun
26	foot	book	food	shoe
27	dress	soap	boat	stove
28	bird	girl	shirt	purse
29	sink	fish	witch	milk
30	boy	dog	frog	ball
31	tree	teeth	train	meat
32	book	boy	coat	boat
33	truck	dog	duck	book
34	bread	stair	dress	bus
35	ham	man	hand	pants
36	door	boy	fork	horse
37	bike	light	slide	knife
38	fruit	dog	frog	clock
39	bird	shirt	purse	shoe
40	spoon	school	shoe	food
41	school	juice	shoe	fruit
42	bread	hair	chair	bear
43	purse	girl	bird	shirt
44	snake	cake	grape	car
45	comb	coat	stove	clown
46	boat	coat	nose	comb
47	man	mouth	house	clown
48	ham	hand	pants	man
49	tongue	duck	truck	cup
50	clown	gum	gun	tongue

Book B

01	grape	cake	train	tree
02	boat	coat	stove	comb
03	hand	pants	man	ham
04	soap	coat	boat	stove
05	train	teeth	meat	tree
06	snake	cake	grape	train
07	book	bus	dress	duck
08	school	shoe	juice	fruit
09	clown	tongue	gun	gum
10	tongue	truck	duck	cup
11	meat	teeth	foot	tree
12	chair	hair	bear	head
13	girl	shirt	bird	purse
14	girl	bird	purse	shirt
15	ball	frog	boy	dog
16	book	food	foot	shoe
17	mouth	horse	house	juice
18	shoe	spoon	school	food
19	shoe	purse	bird	shirt
20	horse	boy	door	fork
21	knife	light	slide	bike
22	hand	man	ham	hair
23	tongue	duck	truck	cup
24	sink	milk	witch	fish
25	comb	boat	soap	coat
26	dog	ball	boy	frog
27	smile	knife	slide	light
28	house	horse	mouth	juice
29	duck	book	bus	dress
30	fish	witch	sink	milk
31	bread	bear	hair	chair
32	truck	cup	gun	tongue
33	coat	nose	stove	boat
34	gum	tongue	gun	truck
35	hand	ham	man	pants
36	school	spoon	shoe	juice
37	cake	grape	tree	train
38	teeth	tree	meat	foot
39	shirt	purse	bird	girl
40	fish	watch	sink	witch
41	shoe	food	spoon	school
42	slide	bike	light	smile
43	head	bread	hand	stair
44	food	foot	shoe	book
45	duck	cup	dog	truck
46	fork	boy	horse	door
47	coat	soap	boat	stove
48	watch	fish	witch	frog
49	clown	car	truck	clock
50	frog	clock	dog	fruit

<u>Shading legend:</u>

Book A: Green = Test Form 1. Yellow = Test Form 2. Red = Both Test Forms. White = foil.

Book B: Green = Test Form 3. Yellow = Test Form 4. Red = Both Test Forms. White = foil

Appendix B

Phonemic analysis of NU-CHIPS (consonants)

	p	t	k	b	d	g	f	θ	v	ð	n	m	ŋ	l	r	tʃ	dʒ	s	z	ʃ	ʒ	w	h	j
ball				1										1										
bear				1																				
bike			1	1																				
bird				1	1																			
boat		1		1																				
bus				1														1						
cake			2																					
clock			2											1										
coat		1	1																					
comb			1									1												
cup	1		1																					
dog					1	1																		
door					1																			
dress					1										1			1						
duck			1		1																			
food					1		1																	
foot		1					1																	
frog						1	1								1									
girl						1								1										
gum						1						1												
gun						1					1													
hair																							1	
ham												1											1	
hand					1						1												1	
head					1																		1	
horse																		1					1	
house																		1					1	
juice																	1	1						
light		1												1										
man											1	1												
meat		1										1												
milk			1									1		1										
mouth								1				1												
nose											1								1					
purse	1																	1						
school			1											1				1						
shirt		1																		1				
shoe																				1				
sink			1															1						

smile												1		1				1						
snake			1								1							1						
soap	1																	1						
spoon	1										1							1						
teeth		1						1																
tongue		1											1											
train		1									1				1									
tree		1													1									
truck		1	1												1									
watch																1						1		
witch																1						1		
Total	4	11	14	6	8	5	3	2	0	0	7	8	1	7	5	2	1	12	1	2	0	2	6	0

Phonemic analysis of NU-CHIPS (vowels)

	KIT	FLEECE	DRESS	TRAP	LOT	FORCE	START	NURSE	GOOSE	STRUT	FOOT	FACE	PRICE	GOAT	CHOICE	MOUTH	NEAR	GOLD	schwa
ball						1													
bear																	1		
bike													1						
bird								1											
boat														1					
bus										1									
cake												1							
clock					1														
coat														1					
comb														1					
cup										1									
dog					1														
door						1													
dress			1																
duck										1									
food									1										
foot											1								
frog					1														
girl								1											
gum										1									
gun										1									
hair																	1		
ham				1															
hand				1															
head			1																
horse						1													
house																1			
juice									1										
light													1						
man				1															
meat		1																	
milk	1																		
mouth																1			
nose														1					
purse								1											
school											1								
shirt								1											
shoe									1										

sink	1																		
smile													1						
snake												1							
soap														1					
spoon									1										
teeth		1																	
tongue										1									
train												1							
tree		1																	
truck										1									
watch					1														
witch	1																		
Total	3	3	2	3	4	3	0	4	4	7	2	3	3	5	0	2	2	0	0

Appendix C

Generation of CVC foil alternatives

Target	CVC Generator Rule 1 Replace first element with any consonant except l, r, w, or j	CVC Generator Rule 2 Replace second element with elements from same class, retaining voicing	CVC Generator Rule 3 Replace third element with elements from same class, retaining voicing	CVC Generator Rule 4 Replace all three elements with different elements from same class, retaining voicing	CVC Generator Rule 5 Replace first element with any consonant of same voicing except l, r, w, or j	CVC Generator Rule 6 Keep first element, replace other elements with elements from same class, retaining voicing	CVC Generator Rule 7 Keep vowels, replace other elements with elements from same class, retaining voicing	CVC Generator Rule 8 Keep third element, replace other elements with elements from same class, retaining voicing	CVC Generator Rule 9 Replace first element with elements from same class, retaining voicing	Rule 10 Semantically related	Rule 11 Completely phonetically unrelated	Rule 12 Other (e.g. replace first element with l, r, w, or j)
bus		boss		deaf, death, gas, gash, dash		bush		gas, boss		cars	dog	
bell	gel, shell, hell	bill, bowl, bull		gill, doll, dill, gull	gel	bill, bowl, bull		bill, dill, gill, bowl, doll, goal, gull			doors	well
dog	hog, fog, cog, jog, bog	dig		bed, bib	jog, dad	dead, dad, dig	God	dig, bag, bug		cat	hat	
ball	tall, shawl, hall, mall	bell		girl	mall			girl		bike	mouse	wall
cars	jars									bus	book	
cake	shake		cape	pipe, type, Pope,	shake	cape, kite, coat	tape, cape			jam	boat	lake
doors	saws									house	fish	
bed	head, dead	bud		dig	dead	bib, bud,	dead	dead, dad, bud, God	dead	house	cows	
hat	bat, mat	hut		ship, sock		hut				shirt	wheel	
book	hook					bat		deck, duck		pad	tongue	
bird	herd	bead, board				barb, bead		bead, board		duck	gun	

bag	tag	bug		dead		bed, bud	dad	dig, bug, dog		hat	pool	
bike	hike		bite			bait, boat				ball	chairs	
boat	coat, goat, moat	bait			goat, moat	bait	goat	bait, gate, goat, bolt	goat	sail	jewel	
mouse	house	mice	mouth	knife		mouth	mouth	mice		rat	kid	
tongue	bung	tong		pin, pen		tin		king, tong		teeth	web	
gun	sun, bun, nun		gum	dam	bun, nun	gum	gum, bun, bung	bin, bun	bun	knife	jet	
house	mouse			safe				face		doors	leg	
chairs	bears											
fish	dish			chef				sash		duck	mat	
fork	cork, pork, chalk		fort	sheep, harp, soup, shirt, suit	pork, cork, chalk	feet, fort	fort	shark, hawk	hawk	knife	gum	
girl	pearl, curl			ball				ball		mum	hen	
cows	sows									pig	wig	
horse	sauce			thief, surf	sauce	hoof	sauce	sauce	sauce	sheep	jam	
duck	puck	deck				dot		deck		bird	log	
bath	path			geese						pool	hug	
keys	bees									cars	sad	
goose	moose, juice	geese		bath	moose, juice	geese		geese		bird	jail	
home	comb, foam, gnome			sign	comb, foam		foam, phone		foam	doors	ring	
jail	tail, veil, sail, hail, mail, nail				veil, mail, nail					room	soap	whale
jars	cars									can	vet	
king	ring			pen, pan		can	tin, pin	tongue, tong		chief	meat	

kite	bite, night	coat		tape, Pope		cape, coat		coat		ball	mouth	
chief	thief				thief					king	jaw	leaf
juice	goose, moose				goose, moose					pears	cat	
moon										sun	lip	
page	cage, gauge, sage				cage, sage		cage	cage	cage	pen	bug	
pool	tool									bath	fan	
vine	sign	vein						vein		weed	pet	line
pad	dad, sad, mad				sad	pig	tag	kid		book	fin	
soap	Pope			hike	Pope	salt		shape		bath	bin	rope
tool	jewel, pool			pill, pole, coal	pool		pool	pill, pole, coal	pool	nail	soup	
pearl	girl, curl	peel			curl	peel	curl	peel, curl	curl	jewel	van	
phone	bone, cone		foam		cone	foam	foam, home	sign			dog	
pole	hole, bowl, coal, doll, fowl (sp?), mole	pill, pool		tool	coal, fowl (sp?), hole	pill, pool	coal	pill, coal	coal	rod	card	
sheep			sheet	fort, heart		sheet, shirt, shark	feet, seat, sheet	harp		cows	tool	
soup	hoop, coup			feet, sheet, heart, fort, shirt	coup, hoop	seat	hoop	sheep, harp	hoop	juice	net	
bars	cars									pole	cat	
cheek	beak	chalk				chart, chalk		chalk		nose	moon	
jug	bug, hug, mug	jog			bug, mug			jog		fork	thumb	
mop	hop, shop, chop	map		net, nut, neck		map, mitt, mat	knot	map, nap		pan	cake	
bone	cone, phone			game						leg	nap	

chain	cane, vein, mane				cane	chime				ring	dam	
doll	mole, pole, bowl, coal, fowl (sp?), hole	dill		bill, gill, bell, bull	bowl, mole	dill	bowl	bill, dill, gill, bell, bowl	bowl	kite	nut	
food		ford				ford		seed, ford, sword		peach	bag	
hole	doll, pole, bowl, coal, fowl (sp?), mole	hill		shell	pole, coal, fowl (sp?)	hill	fowl (sp?)	hill, shell	fowl (sp?)	moat	tongue	
judge	fudge									king	pearl	
peg		pig		kid		pad, pig		pig, tag, cog		nail	road	leg
sail	nail, tail, kale, veil, hail, mail, jail	soil		file, fowl (sp?)	tail, kale, hail	soil	hail	file, hail, soil	hail	boat	wig	
shirt	dirt	sheet		harp, soup, hawk		sheep, sheet, shark		feet, seat, sheet, fort, heart		shoes	nun	
tape	cape, shape	type		kite, coat	cape, shape	type	cape, cake	cape, type, pipe, Pope	cape	pen	whale	
thumb	gum, mum			fin, shin, hen, fan, fang			sun	hem, ham		leg	lake	
mouth			mouse	knife			mouse			nose	dart	
knees	bees									face	wood	
moat	boat, goat, coat, note				boat, goat		note	night		hole	card	
jam	dam, ham				dam					cake	shoes	lamb
cap	map, nap	cup	cat	pit, putt, pot, pick, tick		cup, kit, cat, cut, cot	cat	pip, cup		shirt	gun	
bin	fin, pin, tin, shin, chin	bun		dam, gum		bomb, bun		gun, bun		jar	map	

ham	dam, jam	hem		fin, shin, sun		hem, hen	fan, fang	hem		food	teeth	
knit	mitt, pit, sit	net, knot, nut		map, mop	mitt	nap, net, nut, knot	mitt	mitt, net, mat, nut, knot	mitt	wool	jam	
farm				thorn, horn		fern		seam		pig	net	
tin	bin, pin, fin, shin, chin				pin, fin, shin, chin		pin, king	pin, pen, pan	pin	can	fire	
net	vet, jet	knit, knot, nut	neck	map, mop	vet, jet	nap, knit, nut, knot	neck	mitt, knit, mat, nut, knot		pole	ham	
bees	keys											
chin	tin, pin, bin, fin, shin				pin, tin, fin, shin					nose	mat	
can	fan, pan, van, man				pan, fan	king	pan	pin, tin, pen, pan	pan	tin	wick	
man	pan, fan, van	men			van	mum, men		men, nun		mum	dirt	
nut	hut, putt, cut	knit, net, knot		map, mop		nap, knot		knit, net, mat, knot		seed	mop	
bat	cat, hat, mat		back	deck	mat		back	dot		ball	fang	rat
dart	heart, cart, chart	dirt		beak		dirt	bark	dirt, boot		ball	van	
card	guard	cord				curb, cord		cord		page	knit	yard
fan	man, pan, can, van	fin	fang	hem, thumb	pan, can	fin	ham, fang	fin, shin, hen		house	knot	
van	can, pan, fan, man				man					car	ball	
seal	peel, veal, heel, meal, kneel			shawl, hall	peel, heel		heel	heel, hall, shawl	heel	shark	hose	wheel
head	bed, dead, shed	hood		fog	shed	hood	shed	shed, sad, hood	shed	chin	dart	
cup		cap	cut	pit, pot, tick		cap, cot, cut, cat	cut, putt, puck	pip, cap		fork	jet	
coat	boat, goat, moat, note	kite		tape, pipe, type		cape, kite	Pope, poke	kite		shirt	jam	

nose	hose, toes							maze		chin	guard	
bears	chairs											
foot	soot			ship, hip, shack, sock	soot		soot, hook	hat, soot	soot	nose	ham	
knife				mouth, mace			mice			fork	book	
meat	feet, seat, sheet									ham	zip	
teeth		tooth		purse		tooth	quiche	path, tooth		nose	jet	wreath
gum	mum, thumb		gun	bin	mum	gun	gun, bun, bung	dam		food	vet	
purse	nurse			teeth, tooth		path				bag	map	
comb	home, dome, foam		cone		foam, home	cane, cone, coin	cone			hat	dad	
kid				tub, tab, peg		cub	pig	pad		girl	dam	lid
cheese	keys, bees, knees				peas, keys					ham	pad	
cat	bat, hat, mat	cot, cut	cap	pip, tick	hat	cap, cup, cut, cot	cap	pit, cut, putt, pot, cot		dog	ship	
mat	hat, bat, cat	mitt	map	neck	bat	map, mop, mitt	map, nap	mitt, knit, net, nut, knot		rug	lake	
jet	net, vet				vet, net					car	mop	
vet	jet, net			zip	jet, net					cat	lid	
sad	dad, pad, mad			hug, fog, hog	pad			shed, head, hood		mad	log	
nap	cap, map			mitt	map	knit, net, nut	map, mat	map	map	bed	wig	
map	nap, cap	mop	mat	knit, net, nut, knot, neck	nap	mop, mitt, mat	nap, mat	nap, mop	nap	pad	king	
pan	fan, can, van, man	pin, pen		king	can, fan	pin, pen	can	pin, tin, pen, can	can	pot	cat	
tag	bag			cub, kid		tub	pad	pig, peg, cog		shirt	lick	
dam	ham, jam			bin, gun, bun	jam			gum			chin	

hen	pen		hem	thumb, fang	pen	ham	hem	fin, shin, fan		pig	ship	
bead	seed	board, bird				barb, board, bird		guard, board, bird			shark	
pen	hen, men	pin, pan		king	hen	pin, pan		pin, tin, pan, can		pad	hose	
men	pen, hen	man				mum, man		man, nun		man	cot	
hem		ham	hen	fin, fan, shin, sun, fang		ham, hen	hen	ham		shirt	pot	
fin	tin, bin, pin, shin, chin	fan		hem, ham, thumb	pin, tin, shin, chin	fan	shin	shin, fan, hen	shin	shark	weed	
pin	bin, tin, fin, shin, chin	pen, pan			tin, fin, shin, chin	pen, pan	tin, king	tin, pen, pan	tin		head	
pit	knit, sit, mitt	pot, putt	pip, pick	cup, cap	sit	pip, pot, putt, pick	pip, pick, tick	cat, cut, putt, pot, cot		hole	dog	
pig	dig, fig	peg		cub, tub	fig	pad	kid	peg, tag, cog		hen	sun	wig
bib				dead, dad, God		bed, bud	dig			rag	torch	rib
zip	pip, ship, hip, chip			vet						shirt	mug	lip
fig	pig, dig	fog		head, shed, sad, hood	pig					food	shed	
hog	cog, dog, fog, jog	hug		shed, sad	cog, fog	head, hood	fog	fig	fog	pig	bed	log
pot	cot, dot, knot	pit, putt		cap, cup, tick	cot	pip, pit, putt, pick	cot	pit, cat, cut, putt, cot	cot	pan	gum	
dot	pot, cot, knot				knot			bat		pen	hug	
fog	hog, cog, dog, jog	fig		shed, head, sad, hood	cog, hog	fig	hog	fig	hog		mud	
cot	dot, pot, knot	cat, cut		pip, pick, tick	pot	cap, cup, cut, cat	pot	pit, cat, cut, putt, pot	pot	bed	nun	
sun	bun, gun, nun			hem, ham, fang			thumb	fin, shin, hen, fan		light	dig	
bug	mug, hug, jug	bag	bud	dead	jug, mug	bed, bud	bud	dig, bag, dog		leaf	jet	
bud	mud	bed	bug	dig	mud	bib, bed	bug	dead, bed, dad, God		rose	gun	
cub	tub			pad, pig, peg	tub	kid	tub	tub	tub	fowl (sp?)	sad	

tub	cub			kid, pad, pig, peg	cub		cub	cub	cub	bath	mad	
bun	gun, sun, nun	bin	bung	dam	gun, nun	bin	gum, gun, bung	gun	gun	food	safe	
hug	bug, mug, jug	hog		shed, sad		head, hood		fig			cheese	rug
hut	nut, putt, cut	hat		ship, sack, sock	putt, cut	hip, hop, hat		sit, hat, soot		house	peach	
mug	hug, bug, jug		mud		bug, jug	mud, mad	mud			cup	vet	
mum	gum, thumb				gum	men, man	nun			dad	web	
dad	sad, pad, mad	dead		bib	mad	dead, dig	bag	dead, bed, bud, God		mum	sail	
dead	bed, shed, head	dad		bib, bag	bed	dad, dig	bed	bed, dad, bud, God	bed		bin	
peach	beach	porch, pirch				porch, pirch		porch, torch, pirch		food	hood	
shoes												
face	case, mase				case		safe	house		nose	gun	lace
maze	moles, mares							nose, moles			ring	
barn	naan	burn				beam, bean, burn		bean, girn, burn		house	neck	
torch	porch				porch		porch	peach, porch, pirch	porch	light	pan	

Appendix D

Revised word list (deletions)

Target	Foil 1	Foil 2	Foil 3	Target and Foil 1	Target and Foil 2	Target and Foil 3
bag	rug	rag	mop	FINAL C	V, FINAL C	UNRELATED
bait	gate	goat	fish	V, FINAL C	FINAL C	SEMANTIC
ball	hall	bell	house	V, FINAL C	INITIAL C, FINAL C	UNRELATED
bat	hat	back	ball	V, FINAL C	INITIAL C, V	SEMANTIC, INITIAL C
beach	peach	porch	shell	V, FINAL C	FINAL C	SEMANTIC
beak	cheek	chalk	head	V, FINAL C, SEMANTIC	FINAL C	UNRELATED
bed	head	**bud**	hat	V, FINAL C	INITIAL C, FINAL C	UNRELATED
bike	bite	hike	teeth	INITIAL C, V	V, FINAL C, SEMANTIC	UNRELATED
bird	head	bed	mouth	FINAL C, SEMANTIC	INITIAL C, FINAL C	UNRELATED
bite	bike	hike	teeth	INITIAL C, V	V	SEMANTIC
board	sword	seed	knife	V, FINAL C	FINAL C	UNRELATED
boat	kite	coat	sock	FINAL C	V, FINAL C	UNRELATED
bone	comb	cone	chip	V	V, FINAL C	UNRELATED
book	cheek	beak	head	FINAL C	INITIAL C, FINAL C	UNRELATED
boot	suit	soup	toes	V, FINAL C	V	SEMANTIC
bug	bag	hug	sack	INITIAL C, FINAL C	V, FINAL C	UNRELATED
bus	peach	beach	shell	UNRELATED	INITIAL C	UNRELATED
cap	cat	bat	dog	INITIAL C, V	V	UNRELATED
card	guard	cord	page	V, FINAL C	INITIAL C, FINAL C	SEMANTIC
cat	cot	rack	dog	INITIAL C, FINAL C	V	SEMANTIC
chalk	fork	cheek	pen	V, FINAL C	INITIAL C, FINAL C	SEMANTIC
cheek	beak	chalk	head	V, FINAL C, SEMANTIC	INITIAL C, FINAL C	SEMANTIC
chip	chop	zip	cake	INITIAL C, FINAL C	V, FINAL C	SEMANTIC
chop	chip	zip	cake	INITIAL C, FINAL C	FINAL C	UNRELATED
coat	kite	night	sock	INITIAL C, FINAL C	FINAL C	SEMANTIC
comb	cone	bone	wig	INITIAL C, V	V	SEMANTIC
cone	comb	bone	wig	INITIAL C, V	V, FINAL C	UNRELATED
cot	cat	**pot**	bed	INITIAL C, FINAL C	V, FINAL C	SEMANTIC
dad	sad	head	mum	V, FINAL C	FINAL C	SEMANTIC
dart	heart	dirt	nose	V, FINAL C	INITIAL C, FINAL C	UNRELATED
dirt	heart	dart	nose	FINAL C	INITIAL C, FINAL C	UNRELATED
fan	fin	bin	shark	INITIAL C, FINAL C	FINAL C	UNRELATED
feet	chalk	fork	pen	FINAL C	INITIAL C	UNRELATED
fin	fan	bin	shark	INITIAL C, FINAL C	V, FINAL C	SEMANTIC
fork	chalk	fort	knife	V, FINAL C	INITIAL C, V	SEMANTIC
gate	bait	goat	fish	V, FINAL C	INITIAL C, FINAL C	UNRELATED
goat	boat	bait	sail	V, FINAL C	FINAL C	UNRELATED
gold	card	guard	page	FINAL C	INITIAL C, FINAL C	UNRELATED
guard	card	cord	page	V, FINAL C	FINAL C	UNRELATED
hall	ball	bell	house	V, FINAL C	FINAL C	SEMANTIC, INITIAL C
harp	sharp	heart	knife	V, FINAL C	INITIAL C, V	UNRELATED
hat	bat	back	ball	V, FINAL C	V	UNRELATED
head	bed	hood	mouth	V, FINAL C	INITIAL C, FINAL C, SEMANTIC	SEMANTIC
heart	dart	harp	nose	V, FINAL C	INITIAL C, V	SEMANTIC
hen	pan	pen	chalk	FINAL C	V, FINAL C	UNRELATED
hill	ball	hall	house	FINAL C	INITIAL C, FINAL C	INITIAL C, UNRELATED
home	cone	comb	wig	V	V, FINAL C	UNRELATED
hood	bed	head	hat	FINAL C	INITIAL C, FINAL C, SEMANTIC	INITIAL C, SEMANTIC
hug	bag	bug	sack	FINAL C	V, FINAL C	UNRELATED
hut	bat	hat	ball	FINAL C	INITIAL C, FINAL C	UNRELATED
kick	lock	lick	keys	FINAL C	V, FINAL C	INITIAL C, UNRELATED
kite	night	**note**	ball	V, FINAL C	FINAL C	SEMANTIC
knees	toes	nose	head	FINAL C	INITIAL C, FINAL C	SEMANTIC
knit	nut	sit	seed	INITIAL C, FINAL C	V, FINAL C	UNRELATED
lake	sock	lock	keys	FINAL C	INITIAL C, FINAL C	UNRELATED

leaf	leash	thief	dog	INITIAL C, V	V, FINAL C	UNRELATED
leash	leaf	thief	dog	INITIAL C, V	V	SEMANTIC
leg	log	dog	chin	INITIAL C, FINAL C	FINAL C	SEMANTIC
lick	lock	sock	keys	INITIAL C, FINAL C	FINAL C	UNRELATED
light	bike	bite	teeth	V	V, FINAL C	UNRELATED
lip	ship	lick	sail	V, FINAL C	INITIAL C, V	UNRELATED
lobe	road	robe	shirt	V	V, FINAL C	UNRELATED
lock	lick	sock	keys	INITIAL C, FINAL C	V, FINAL C	SEMANTIC
log	leg	dog	chin	INITIAL C, FINAL C	V, FINAL C	UNRELATED
man	fin	fan	shark	FINAL C	V, FINAL C	UNRELATED
mat	feet	meat	shoes	FINAL C	INITIAL C, FINAL C	UNRELATED
meat	feet	fort	shoes	V, FINAL C	FINAL C	UNRELATED
mop	chip	chop	cake	FINAL C	V, FINAL C	UNRELATED
mouse	mouth	house	tongue	INITIAL C, V, SEMANTIC	V, FINAL C	SEMANTIC
mouth	mouse	house	tongue	INITIAL C, V, SEMANTIC	V	SEMANTIC
night	coat	kite	sock	FINAL C	V, FINAL C	UNRELATED
nose	toes	toys	head	V, FINAL C, SEMANTIC	FINAL C	SEMANTIC
nurse	purse	noose	bag	V, FINAL C	INITIAL C, FINAL C	UNRELATED
nut	knit	sit	seed	INITIAL C, FINAL C	FINAL C	SEMANTIC
pan	pen	man	chalk	INITIAL C, FINAL C	V, FINAL C	UNRELATED
park	shark	sharp	fish	V, FINAL C	V	UNRELATED
peach	beach	porch	shell	V, FINAL C	INITIAL C, FINAL C	UNRELATED
peg	log	leg	chin	FINAL C	V, FINAL C	UNRELATED
pen	pan	man	chalk	INITIAL C, FINAL C	FINAL C	SEMANTIC
puck	shark	park	fish	FINAL C	INITIAL C, FINAL C	UNRELATED
purse	nurse	noose	bag	V, FINAL C	FINAL C	SEMANTIC
quiche	leaf	leash	dog	V	V, FINAL C	UNRELATED
rag	rug	bag	mop	INITIAL C, FINAL C	V, FINAL C	SEMANTIC
rat	cat	rack	dog	V, FINAL C, SEMANTIC	INITIAL C, V	SEMANTIC
road	robe	toad	shirt	INITIAL C, V	V, FINAL C	UNRELATED
robe	road	toad	shirt	INITIAL C, V	V	SEMANTIC
rock	sock	rack	boot	V, FINAL C	INITIAL C, FINAL C	UNRELATED
rug	rag	bug	mop	INITIAL C, FINAL C	V, FINAL C	UNRELATED
sack	rock	sock	boot	FINAL C	INITIAL C, FINAL C	UNRELATED
sad	dad	head	mum	V, FINAL C	FINAL C	UNRELATED
shark	park	sharp	fish	V, FINAL C	INITIAL C, V	SEMANTIC
sharp	harp	heart	knife	V, FINAL C	V	SEMANTIC
sheep	harp	sharp	knife	FINAL C	INITIAL C, FINAL C	UNRELATED
sheet	shirt	dirt	bed	INITIAL C, FINAL C, SEMANTIC	FINAL C	SEMANTIC
ship	lip	lick	sail	V, FINAL C	V	SEMANTIC
shirt	sheet	dirt	bed	INITIAL C, FINAL C, SEMANTIC	V, FINAL C	UNRELATED
sock	rock	rack	boot	V, FINAL C	FINAL C	SEMANTIC
south	mouse	mouth	tongue	V	V, FINAL C	UNRELATED
suit	boot	soup	toes	V, FINAL C	INITIAL C, V	UNRELATED
sword	dad	sad	mum	FINAL C	INITIAL C, FINAL C	UNRELATED
tap	cat	cap	dog	V	V, FINAL C	UNRELATED
toes	nose	toys	head	V, FINAL C, SEMANTIC	INITIAL C, FINAL C	SEMANTIC
van	man	**men**	bus	V, FINAL C	FINAL C	SEMANTIC
vine	man	van	bus	FINAL C	INITIAL C, FINAL C	UNRELATED
zap	ship	zip	suit	FINAL C	INITIAL C, FINAL C	UNRELATED
zip	ship	**shop**	suit	V, FINAL C	FINAL C	SEMANTIC

Appendix E

Revised word list (inappropriate targets and foils)

Target	Foil 1	Foil 2	Foil 3		Target and Foil 1	Target and Foil 2	Target and Foil 3
nose	toes	toys	head		V, FINAL C, SEMANTIC	FINAL C	SEMANTIC
bait	gate	goat	fish		V, FINAL C	FINAL C	SEMANTIC
beach	peach	porch	shell		V, FINAL C	FINAL C	SEMANTIC
dad	sad	head	mum		V, FINAL C	FINAL C	SEMANTIC
hall	ball	bell	house		V, FINAL C	FINAL C	SEMANTIC, INITIAL C
kite	night	**note**	ball		V, FINAL C	FINAL C	SEMANTIC
purse	nurse	noose	bag		V, FINAL C	FINAL C	SEMANTIC
sock	rock	rack	boot		V, FINAL C	FINAL C	SEMANTIC
van	man	**men**	bus		V, FINAL C	FINAL C	SEMANTIC
zip	ship	**shop**	suit		V, FINAL C	FINAL C	SEMANTIC
beak	cheek	chalk	head		V, FINAL C, SEMANTIC	FINAL C	UNRELATED
bag	rag	rug	mop		V, FINAL C	FINAL C	UNRELATED
board	sword	seed	knife		V, FINAL C	FINAL C	UNRELATED
boat	coat	kite	sock		V, FINAL C	FINAL C	UNRELATED
goat	boat	bait	sail		V, FINAL C	FINAL C	UNRELATED
guard	card	cord	page		V, FINAL C	FINAL C	UNRELATED
hen	pen	pan	chalk		V, FINAL C	FINAL C	UNRELATED
hug	bug	bag	sack		V, FINAL C	FINAL C	UNRELATED
night	kite	coat	sock		V, FINAL C	FINAL C	UNRELATED
man	fan	fin	shark		V, FINAL C	FINAL C	UNRELATED
meat	feet	fort	shoes		V, FINAL C	FINAL C	UNRELATED
mop	chop	chip	cake		V, FINAL C	FINAL C	UNRELATED
peg	leg	log	chin		V, FINAL C	FINAL C	UNRELATED
sad	dad	head	mum		V, FINAL C	FINAL C	UNRELATED
kick	lick	lock	keys		V, FINAL C	FINAL C	INITIAL C
cheek	beak	chalk	head		V, FINAL C, SEMANTIC	INITIAL C, FINAL C	SEMANTIC
head	bed	hood	mouth		V, FINAL C	INITIAL C, FINAL C, SEMANTIC	SEMANTIC
card	guard	cord	page		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
chalk	fork	cheek	pen		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
chip	zip	chop	cake		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
cot	**pot**	cat	bed		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
fin	bin	fan	shark		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
lock	sock	lick	keys		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
rag	bag	rug	mop		V, FINAL C	INITIAL C, FINAL C	SEMANTIC
shirt	dirt	sheet	bed		V, FINAL C	INITIAL C, FINAL C, SEMANTIC	UNRELATED
bed	head	**bud**	hat		V, FINAL C	INITIAL C, FINAL C	UNRELATED
ball	hall	bell	house		V, FINAL C	INITIAL C, FINAL C	UNRELATED
bug	hug	bag	sack		V, FINAL C	INITIAL C, FINAL C	UNRELATED
dart	heart	dirt	nose		V, FINAL C	INITIAL C, FINAL C	UNRELATED
gate	bait	goat	fish		V, FINAL C	INITIAL C, FINAL C	UNRELATED
knit	sit	nut	seed		V, FINAL C	INITIAL C, FINAL C	UNRELATED
log	dog	leg	chin		V, FINAL C	INITIAL C, FINAL C	UNRELATED
nurse	purse	noose	bag		V, FINAL C	INITIAL C, FINAL C	UNRELATED
pan	man	pen	chalk		V, FINAL C	INITIAL C, FINAL C	UNRELATED
peach	beach	porch	shell		V, FINAL C	INITIAL C, FINAL C	UNRELATED
rock	sock	rack	boot		V, FINAL C	INITIAL C, FINAL C	UNRELATED
rug	bug	rag	mop		V, FINAL C	INITIAL C, FINAL C	UNRELATED
rat	cat	rack	dog		V, FINAL C, SEMANTIC	INITIAL C, V	SEMANTIC
bat	hat	back	ball		V, FINAL C	INITIAL C, V	INITIAL C, SEMANTIC
fork	chalk	fort	knife		V, FINAL C	INITIAL C, V	SEMANTIC
heart	dart	harp	nose		V, FINAL C	INITIAL C, V	SEMANTIC
shark	park	sharp	fish		V, FINAL C	INITIAL C, V	SEMANTIC
bike	hike	bite	teeth		V, FINAL C, SEMANTIC	INITIAL C, V	UNRELATED
cone	bone	comb	wig		V, FINAL C	INITIAL C, V	UNRELATED

harp	sharp	heart	knife		V, FINAL C	INITIAL C, V	UNRELATED
leaf	thief	leash	dog		V, FINAL C	INITIAL C, V	UNRELATED
lip	ship	lick	sail		V, FINAL C	INITIAL C, V	UNRELATED
mouse	house	mouth	tongue		V, FINAL C	INITIAL C, V	UNRELATED
road	toad	robe	shirt		V, FINAL C	INITIAL C, V	UNRELATED
suit	boot	soup	toes		V, FINAL C	INITIAL C, V	UNRELATED
boot	suit	soup	toes		V, FINAL C	V	SEMANTIC
sharp	harp	heart	knife		V, FINAL C	V	SEMANTIC
ship	lip	lick	sail		V, FINAL C	V	SEMANTIC
bone	cone	comb	chip		V, FINAL C	V	UNRELATED
home	comb	cone	wig		V, FINAL C	V	UNRELATED
park	shark	sharp	fish		V, FINAL C	V	UNRELATED
quiche	leash	leaf	dog		V, FINAL C	V	UNRELATED
light	bite	bike	teeth		V, FINAL C	V	UNRELATED
lobe	robe	road	shirt		V, FINAL C	V	UNRELATED
hat	bat	back	ball		V, FINAL C	V	UNRELATED
south	mouth	mouse	tongue		V, FINAL C	V	UNRELATED
tap	cap	cat	dog		V, FINAL C	V	UNRELATED
toes	nose	toys	head		V, FINAL C, SEMANTIC	INITIAL C, FINAL C	SEMANTIC
hood	bed	head	hat		FINAL C	INITIAL C, FINAL C, SEMANTIC	INITIAL C, SEMANTIC
sheet	dirt	shirt	bed		FINAL C	INITIAL C, FINAL C, SEMANTIC	SEMANTIC
leg	dog	log	chin		FINAL C	INITIAL C, FINAL C	SEMANTIC
knees	toes	nose	head		FINAL C	INITIAL C, FINAL C	SEMANTIC
coat	night	kite	sock		FINAL C	INITIAL C, FINAL C	SEMANTIC
nut	sit	knit	seed		FINAL C	INITIAL C, FINAL C	SEMANTIC
pen	man	pan	chalk		FINAL C	INITIAL C, FINAL C	SEMANTIC
hut	bat	hat	ball		FINAL C	INITIAL C, FINAL C	UNRELATED
gold	card	guard	page		FINAL C	INITIAL C, FINAL C	UNRELATED
lake	sock	lock	keys		FINAL C	INITIAL C, FINAL C	UNRELATED
lick	sock	lock	keys		FINAL C	INITIAL C, FINAL C	UNRELATED
dirt	heart	dart	nose		FINAL C	INITIAL C, FINAL C	UNRELATED
fan	bin	fin	shark		FINAL C	INITIAL C, FINAL C	UNRELATED
book	cheek	beak	head		FINAL C	INITIAL C, FINAL C	UNRELATED
bird	head	bed	mouth		FINAL C	INITIAL C, FINAL C	UNRELATED
chop	zip	chip	cake		FINAL C	INITIAL C, FINAL C	UNRELATED
mat	feet	meat	shoes		FINAL C	INITIAL C, FINAL C	UNRELATED
puck	shark	park	fish		FINAL C	INITIAL C, FINAL C	UNRELATED
sack	rock	sock	boot		FINAL C	INITIAL C, FINAL C	UNRELATED
sheep	harp	sharp	knife		FINAL C	INITIAL C, FINAL C	UNRELATED
sword	dad	sad	mum		FINAL C	INITIAL C, FINAL C	UNRELATED
zap	ship	zip	suit		FINAL C	INITIAL C, FINAL C	UNRELATED
vine	man	van	bus		FINAL C	INITIAL C, FINAL C	UNRELATED
hill	ball	hall	house		FINAL C	INITIAL C, FINAL C	INITIAL C
cat	rack	cot	dog		V	INITIAL C, FINAL C	SEMANTIC
robe	toad	road	shirt		V	INITIAL C, V	SEMANTIC
mouth	house	mouse	tongue		V	INITIAL C, V	SEMANTIC
leash	thief	leaf	dog		V	INITIAL C, V	SEMANTIC
comb	bone	cone	wig		V	INITIAL C, V	SEMANTIC
bite	hike	bike	teeth		V	INITIAL C, V	SEMANTIC
cap	bat	cat	dog		V	INITIAL C, V	UNRELATED
feet	fork	chalk	pen		INITIAL C	FINAL C	UNRELATED
bus	beach	peach	shell		INITIAL C	UNRELATED	UNRELATED

Appendix F

Phonemic analysis of new word list (consonants)

	t	k	b	p	d	g	f	θ	v	ð	n	m	ŋ	l	r	tʃ	dʒ	s	z	ʃ	ʒ	w	h	j
back		1	1																					
bag			1			1																		
ball			1											1										
bat	1		1																					
beach			1													1								
beak		1	1																					
bed			1		1																			
bell			1											1										
bike		1	1																					
bin			1								1													
bird			1		1																			
bite	1		1																					
boat	1		1																					
bone			1								1													
book		1	1																					
boot	1		1																					
bug			1			1																		
bus			1															1						
cage		1															1							
cake		2																						
cap		1		1																				
card		1			1																			
cat	1	1																						
chalk		1														1								
chin											1					1								
chip				1												1								
coat	1	1																						
comb		1										1												
cone		1									1													
cot	1	1																						
dad					2																			
dirt	1		1																					
dog			1			1																		
duck		1			1																			
fan							1				1													
feet	1						1																	
fork		1					1																	
gate	1					1																		
goat	1					1																		
hall														1									1	

hat	1																					1	
head					1																	1	
heart	1																					1	
hen											1											1	
hood					1																	1	
house																	1					1	
hug						1																1	
hut	1																					1	
keys		1																1					
king		1											1										
kite	1	1																					
knees											1							1					
knife							1				1												
leaf							1							1									
leg						1								1									
lick		1												1									
light	1													1									
lock		1												1									
log						1								1									
man											1	1											
meat	1											1											
mop				1								1											
mouse												1					1						
mouth								1				1											
mum												2											
night	1										1												
nose											1							1					
note	1										1												
nurse											1						1						
nut	1										1												
page				1													1						
pan				1							1												
park		1		1																			
peach				1												1							
pen				1							1												
pig				1		1																	
purse				1													1						
road					1										1								
rock		1													1								
rose															1			1					
rug						1									1								
sack		1															1						
sad					1												1						
seed					1												1						

shark		1																	1					
sheep				1															1					
shell														1					1					
ship				1															1					
shirt	1																		1					
shop				1															1					
sock		1																1						
soup				1														1						
suit	1																	1						
sword					1													1						
tap	1			1																				
tongue	1												1											
van									1		1													
zip				1															1					
Totals	24	27	20	16	12	10	5	1	1	0	17	8	2	10	4	5	2	12	5	6	0	0	9	0

Phonemic analysis of new word list (vowels)

	KIT	FLEECE	DRESS	TRAP	LOT	FORCE	START	NURSE	GOOSE	STRUT	FOOT	FACE	PRICE	GOAT	CHOICE	MOUTH	NEAR	SQUARE	GOLD	schwa
back				1																
bag				1																
ball						1														
bat				1																
beach		1																		
beak		1																		
bed			1																	
bell			1																	
bike													1							
bin	1																			
bird								1												
bite													1							
boat														1						
bone														1						
book											1									
boot									1											
bug										1										
bus										1										
cage												1								
cake												1								
cap				1																
card							1													
cat				1																
chalk						1														
chin	1																			
chip	1																			
coat														1						
comb														1						
cone														1						
cot					1															
dad				1																
dirt								1												
dog					1															
duck										1										
fan				1																
feet		1																		
fork						1														
gate												1								

goat														1						
hall						1														
hat				1																
head			1																	
heart							1													
hen			1																	
hood											1									
house																1				
hug										1										
hut										1										
keys		1																		
king	1																			
kite													1							
knees		1																		
knife													1							
leaf		1																		
leg			1																	
lick	1																			
light													1							
lock					1															
log					1															
man				1																
meat		1																		
mop					1															
mouse																1				
mouth																1				
mum										1										
night													1							
nose														1						
note														1						
nurse								1												
nut										1										
page												1								
pan				1																
park							1													
peach		1																		
pen			1																	
pig	1																			
purse								1												
road														1						
rock					1															
rose														1						
rug										1										
sack				1																

sad				1																
seed		1																		
shark							1													
sheep		1																		
shell			1																	
ship	1																			
shirt								1												
shop					1															
sock					1															
soup									1											
suit									1											
sword						1														
tap				1																
tongue										1										
van				1																
zip	1																			
Total	8	10	7	14	8	5	4	5	3	9	2	4	6	10	0	3	0	0	0	0

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